MedSystem III™ Troubleshooting Tip Sheet

For most common errors.

Error Codes	Troubleshooting Steps
(6,3):	1. Check to see if any Air-in-Line Sensors have become disconnected. 2. Use a known good Air-in-Line Sensor to find out which Air-in-line sensors are defective. Replace defective Air-in-line sensors*.
(16,X):	1. Clean Opto Module and do CID/LIP calibration. 2. Replace Opto Module*.
Timing Error **(31,3):**	1. Reseat Top Board. 2. Check Fuse. 3. Check Battery. 4. Replace Power Supply*. 5. Replace MEA*.
(33,3)	1. Reseat Top Board and EPOM. 2. Replace MEA*.
(40,X):	1. Reseat Top Board. 2. Replace Power Supply*.
(95,X): X = Channel # 0-A 1-B 2-C	1. Check to see if any Air-in-Line Sensors have become disconnected. 2. Replace the Air-in-Line Sensor* on whichever channel causes the pump to go into alarm when started.
(259):	1. Clean channel and do FSOD calibration. 2. Switch drive module with another channel. If error moves with with Drive Module replace Drive Module*. If error stays in same channel replace MEA*.
(263):	1. Do Pressure calibration. also check Lithunim batt

(272): 1. Do CID/LIP calibration.

pump will not home
(275): 1. Clean and Lubricate channel, do FSOD calibration.
2. Switch drive module with another channel. If error moves with with Drive Module replace Drive Module*. If error stays in same channel replace MEA*.

(276); 1. Do FSOD calibration.

(289)/(290) 1. Clean Encoder Disk. Make sure dust cover is properly installed. Do FSOD calibration.
2. Switch drive module with another channel. If error moves with with Drive Module replace Drive Module*. If error stays in same channel replace MEA*.

(292) 1. Reset faults.

(293) 1. Reset faults.

(301)/(24) 1. Replace MEA*.

(302)/(47) 1. Reseat Top Board.
2. Check Fuse.
3. Check Battery.
4. Replace Power Supply Board*.

(305)/(88) 1. Replace Power Supply Board*.
2. Replace MEA*.

(303)/(67) 1. Reseat Top Board.
2. Check Fuse.
3. Check Battery.
4. Replace MEA*.

(311) 1. Reseat Top Board.
2. Check Fuse.
3. Check Battery.
4. Replace Power Supply Board*.

(313) 1. Replace Air-in-Line Sensor *.

(314) 1. Replace Air-in-Line Sensor*.

(315) 1. Replace Air-in-Line Sensor*.

(326) 1. Do FSOD.
5.0 Software only 2. Replace MEA*.

* Follow level of testing Guide Lines in Service Bulletin 404A.

IVAC
MEDICAL SYSTEMS

Medsystem III™ FSOD

May 8, 1996

Inquiries have been made as to the possible causes and suggested remedies for **nuisance fluid side occlusion alarms.** The following information is not an all inclusive study on the subject, but intended as a quick reference guide.

---

1. SOLUTION VISCOSITY

   Viscous solutions obviously requires more effort in moving through the set. The algorithm written into the FSOD system is designed to compensate for fluid viscosity but certain factors can complicate the flow. These factors include using a 60 drop set instead of a 20 and knowledge regarding the use of the confirm key.

   Suggestions: If this appears to be the cause, suggest a 20dpm set be used.

2. MOTOR

   It is possible that over extended periods of non-use, the motor and drive belt may become stiff as in any mechanical assembly. If we analyze channel utilization we would observe that typically, for a single infusion, ch. A is selected, for two lines chs. A and B are selected. On the average - ch. C is chosen only after chs. A and B are occupied. The result is that ch. C has longer periods of non-use and quite often it is this channel that is associated with nuisance FSOD alarms.

   Suggestions: This issue is easily overcome by simply running the instrument at a rate of 999 for a period of 4 to 5 hours - this is normally done by biomed.

3. DISPOSABLE

   The pumping chamber is sealed by a silicone piston sleeve in which the plastic piston is inserted. The amount of energy required by the motor to drive the piston up and down will have an impact on FSOD. An example of this would be in cases where insufficient lubricant was applied in the manufacturing of the cassette. Contamination, spills, etc..., will also degrade the piston mobility.

   Suggestions: Once you have determined that the piston portion of the cassette is stiff for whatever reason, I recommend you install a new cassette. *If it appears to be a manufacturing problem take action to return the set for analysis.*

4. CALIBRATION

   Annual calibration is recommended to account for any wear or drift in the sensor systems. A variety of symptoms including nuisances FSOD alarms could result from failing to perform the calibration.

   Suggestions: Calibrate the instrument.

5. CONTAMINATION

   Spills, leaking sets and other forms of contamination will have a negative impact on the FSOD system. As the solution begins to dry, friction develops between the moving parts. The increased load on the motor triggers FSOD alarms.

   Suggestions: Encourage the institution to maintain a cleaning regimen as outlined in the recommended cleaning procedure for MSIII, hospitals that do, benefit greatly.

NOTE - In any case where the administration set is found to be leaking, it is vitally important that the set be returned to IVAC-Creedmoor for analysis.

Lee Wengronowitz
Sr. Tech. Support Spec.

Corporate Office ■ 10221 Wateridge Circle ■ San Diego, California 92121-1579
P.O. Box 85335 ■ San Diego, California 92186-5335 ■ (619) 458-7000
Web Site: http://www.ivac.com/~ivac/

MEMO

Date 11-19-98

To: Technical Support

Cc: Rob Pecsar, Tam Tran

From: Hiep Dinh

Subject: Resetting the DLE (Version 2.00) Password Instruction

---

1. Background

At the first time of running DLE, the program asks the users to set the DLE password. This password will be saved in the hidden file, named **dle.pwl**, and can not be changed.

The only way to change the DLE password is to reset it by deleting the **dle.pwl** file. The **dle.pwl** file is located in the directory where the DLE application was installed (default at c:\msiiidle)

2. Resetting Password for Windows NT

1. Exit DLE program.
2. Launch 'Windows NT Explorer' (Start, Program, Windows NT Explorer).
3. Open 'Msiiidle' or 'msiiidle' folder, or the folder where DLE was installed.
4. Click 'View'.
5. Click 'Options'.
6. Click 'View' tab.
7. Record the settings on this window.
8. Click on 'Show all files' button.
9. Uncheck 'Hide file extensions for known file types' box.
10. Click 'Apply' button.
11. Click 'OK' button.
12. On the right hand side window, click the dle.pwl icon to highlight it.
13. Hit the 'Delete' key on the keyboard.
14. Click 'Yes' button on the 'Confirm File Delete' popup window.
15. Verify that there is no dle.pwl file in the right hand side window.
16. Click 'View'.

17. Click 'Options'.
18. Click 'View' tab.
19. Reset the settings on this window as recorded earlier.
20. Click 'Apply' button.
21. Click 'OK' button.
22. Close the 'Windows NT Explorer' window.
23. Start the DLE program. Enter and confirm a new password.

3. Resetting Password for Windows 95

1. Exit DLE program.
2. Launch 'Windows Explorer' (Start, Program, Windows Explorer).
3. Open 'Msiiidle' or 'msiiidle' folder, or the folder where DLE was installed.
4. Click 'View'.
5. Click 'Folder Options...'.
6. Click 'View' tab.
7. Record the settings on this window.
8. Uncheck 'Hide file extensions for known file types' box under Files and Folders.
9. Click on 'Show all files' button under Hidden files.
10. Click 'Apply' button.
11. Click 'OK' button.
12. On the right hand side window, click the dle.pwl icon to highlight it.
13. Hit the 'Delete' key on the keyboard.
14. Click 'Yes' button on the 'Confirm File Delete' popup window.
15. Verify that there is no dle.pwl file in the right hand side window.
16. Click 'View'.
17. Click 'Folder Options...'.
18. Click 'View' tab.
24. Reset the settings on this window as recorded earlier.
19. Click 'Apply' button.
20. Click 'OK' button.
21. Close the 'Windows Explorer' window.
22. Start the DLE program. Enter and confirm a new password.

4. Resetting Password for Windows 3.1X

1. Exit DLE program.
2. Launch 'File Manager'.
3. Open 'msiiidle' folder, or the folder where DLE was installed.
4. Click 'View'.

5. Click 'By File Type...'.
6. Record the settings on this window.
7. Check 'Show Hidden/System Files'.
8. Click 'OK' button.
9. On the right hand side window, click the dle.pwl icon to highlight it.
10. Hit the 'Delete' key on the keyboard.
11. Click 'OK' button on the 'Delete' popup window.
12. Click 'Yes' button on the 'Confirm File Delete' popup window.
13. Verify that there is no dle.pwl file in the right hand side window.
14. Click 'View'.
15. Click 'By File Type...'.
16. Reset the settings on this window as recorded earlier.
17. Click 'OK' button.
18. Close the 'File Manager' window.
19. Start the DLE program. Enter and confirm a new password.

[end]

IVAC MEDICAL SYSTEMS

NOTIFICATION OF PRACTICES TO REDUCE THE OCCURRENCE OF PUMP LATCH CLOSED ALARMS FOR THE IVAC® MEDSYSTEM III™ INFUSION PUMP

Attention: **Sales Force**

IVAC Medical Systems, Inc. has determined that the occurrence of pump latch closed alarms can be reduced with the following practices:

- Fully extending the cassette slide clamp when removing the cassette from the pump as illustrated in Figure 1 below.
- Turning the pump on before inserting the cassette into the pump.
- Stopping the channel before removing the cassette from the pump.
- Removing the cassette from the pump before turning the pump off.

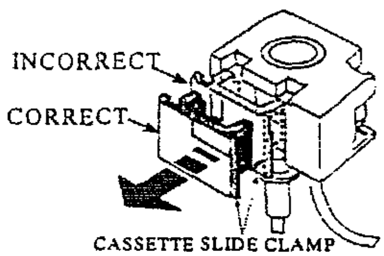


Figure 1

To address a pump latch closed alarm, the procedure below should be followed:

- Using only your finger, push down the closed pumping latch jaw until it snaps open as illustrated in Figure 2 below.
- If the pumping latch jaw is visibly broken, press the "SERVICE" softkey and contact qualified service personnel.

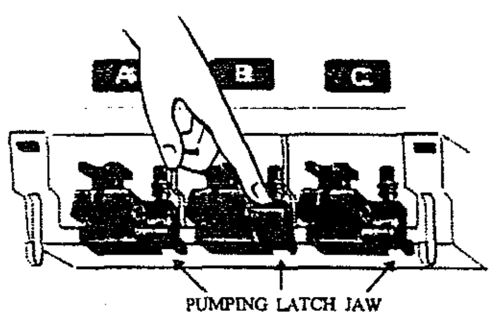


Figure 2

If you require further information regarding this notification, please call IVAC's Corporate STAT line using our toll free number (800) 547-7828.

MedSystem III
SPARE PARTS LIST

Revised 11 May 00

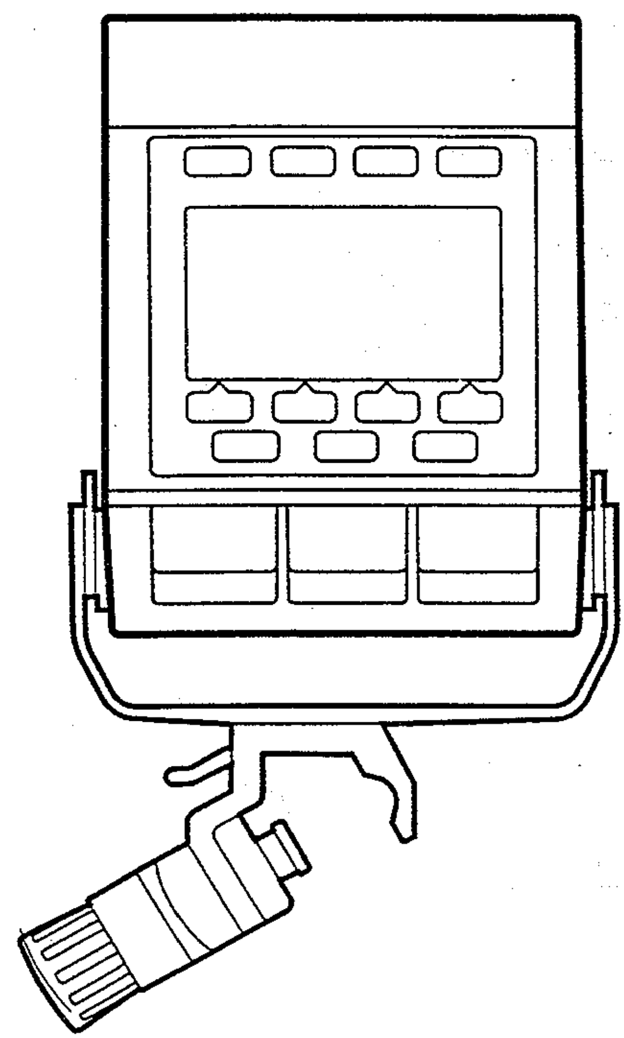
P/N	Description	Qty[1]	Unit Price[2]
2860505	Top Label Kit(2ea)	2	15.48
2860521	Lower Housing Kit	2	26.24
2860539	Lower Housing Clip(2es)	2	12.41
2860554	Main Housing Partial Assembly (2860/3)	2	167.71
143816	Main Housing Partial Assembly (2865)	2	167.71
2860588	Graphic Label Kit	2	20.25
2860596	Pad Kit	2	14.51
2860604	Dust Cap Kit,(5ea=1Pump)	2	89.10
2860620	Display,Module	2	461.25
144980	Power PCBAKit *(Reconditioned)*	1	250.00
143013	Power PCBAKit (2863/5)	1	486.48
142595	Main Electronics Assy 2860, (ASIC)	1	589.36
142593	Main Electronics Assy 2860, With 5.0 Software (ASIC)	1	634.82
142594	Main Electronics Assy 2860, With 3.5 Software (ASIC)	1	689.38
136615	MEA kit 2863/5	1	507.04
143028	Audio/Connector PCB Kit 2863/5	1	210.33
143210	Audio/Connector PCB Kit 2860	1	221.25
[illegible]60653	3A FuseKit,(5pcs)	2	36.54
2860703	Kit,Battery Pack Assy	5	90.00
2860530	NiCad Housing Assy Kit	1	32.46
2860729	Assy,Memory,Battery,Backup	2	60.14
2860745	Drive Module Kit	2	500.00
2860752	Drive,Belts, 15/pkg	1	34.88
2860760	Motor Kit	2	252.15
145799	Valve/Actuator Kit(3sets=1Pump)	2	143.01
2860802	Air-In-Line Sensor Kit 2860	2	184.20
2860516	Air-In-Line Sensor Kit,2863/5	1	148.20
2860950	Air-In-Line Sensor Screws(60screws=30sets=10Pumps)	1	23.97
2860828	Slide Links(15pcs=5Pumps)	2	115.00
2860836	Serv Assy,Pump Shaft	2	80.46
2860844	Serv Assy,Pump Shaft Seal*(15pcs)*	2	141.21
2860851	Serv Assy,Module,Opto	5	100.81
2860869	Chassis Mount Service Kit,,(2sets=1Pump)	2	80.26
2860877	Knob Assembly Kit	2	105.84
2860885	Slide Knob Assembly	2	16.29
2860893	Kit,Connector,Repair(3sets=1Pump)	2	55.67
2860919	Kit,Pressure Transducer	2	121.00

[1] Quantities shown are usage with 25 instruments in one (1) year's time.
[2] Prices shown are subject to change. **Parts Ordering 1 (800) 482-4822**
[3] Always specify revision number when ordering.
[4] Reconditioned prices include exchange board. A core charge will be added if a defective board is not returned.
Reconditioned logic boards do not include software.
NOTE: QTY unit of measure is "each" unless otherwise indicated. A/R - As Required

138356	Tape, Pressuer Trasducer Cover	A/R	0.70
2860794	Pump Latch Kit	2	29.32
2860968	Pole Clamp Chass Mount Screws(40screws=20sets=10Pumps)	1	17.87
2861065	Clip,Adapter,AC(5pcs)	3	27.33
2861089	Locking AC Adapter	2	150.00
2861123	Universal Pole Clamp	2	200.00
2861131	LCD Backlight	2	61.29
2863079	Cap, Slide, Knob Assembly	2	58.50
2861461	Calibration Device Assy*(Not in any Service Agreement)*	1	241.52
2860525	FMS2.2c,Service Kit,With Cables(2.1j)*(Not in any Service Agrmnt)* ***For use with pump software versions 4.0 or greater.***	1	225.00
2860526	FMS2.2c,Service Kit,W/o Cables(2.1j)*(Not in any Service Agrmnt)* ***For use with pump software versions 4.0 or greater.***	1	95.00
2861107	FMS,Service Kit,With Cables(2.1j)*(Not in any Service Agreement)* ***For use with pump software versions 3.3 & 3.5.***	1	225.00
2861115	FMS,Service Kit,W/o Cables(2.1j)*(Not in any Service Agreement)* ***For use with pump software versions 3.3 & 3.5.***	1	95.00
143572	FMS2.24Service Kit with Cables and DLE ***For use with pump software versions 4.0 or greater***	A/R	400.00
2863087	Kit,Communication Cable	1	136.74
2861462	Adaptor 9D FEM to 25	A/R	10.00
2863012	Manual,Service,Technical	1	85.00
2863277	Manual, Maintenance, Field	1	25.00
140155	**Kit,DFU, 2863***(For use with pump software version 3.5.)*	**1**	**25.00**
145265	**Kit,DFU, 286X***(For use with pump software version 4.0 & greater.)*	**1**	**25.00**
145370	5.0g-A Upgrade Kit*(ASIC Pumps Model 2863)*	**A/R**	**95.00**
2860529	Communication Protocol Manual	A/R	25.00
2863277	2.1 FMS Manual	A/R	25.00
140799	2.2 FMS Manual	A/R	25.00
8631A	Syringe Holder	A/R	13.50
141585	Die cast Chassis	A/R	157.50
136983	MSIII Operating Inst. Lbl. *(for front of pump)*	A/R	10.12
143010	Front Panel, Key Pad (2860/3)	A/R	105.00
143817	Front Panel, Key Pad (2865)	A/R	105.00
2863351	Quick Ref Guide 5.0	A/R	9.92
143553	Carrying Case	A/R	125.00

ALARIS™
MEDICAL SYSTEMS

Technical Service Manual
IVAC® MedSystem III® Infusion System



This device is protected under one or more of the following U.S. Patents:

4,814,685	4,878,896	5,053,747
4,818,190	4,884,065	5,064,412
4,832,299	4,919,596	5,126,616
4,850,817	4,940,399	5,149,603
4,856,340	4,950,235	5,176,343
4,863,425	5,000,663	5,176,631
4,872,813	5,006,110	
D 309,188	5,009,641	
D 309,662	5,041,086	

Other U.S. and/or foreign patents may be pending.

Certification has been granted by the following agencies:

UL 544

CSA® Standard C22.2 No. 125
Risk Class 2G

ALARIS™ Medical Systems, Inc.

IVAC® MedSystem III™

Models 2860 and 2863

Multi-Channel Infusion Pump

Technical Service Manual

MedSystem III® Technical Service Manual

This service manual is subject to change without notification. For current technical information please call Product Support at (800) 854-7128 ext. 6003, or write ALARIS Medical Systems, Inc., P.O. Box 85335, San Diego, CA 92126-5335, attention Product Support.

Printed in the U.S.A.

Manual part number 139981B

WARRANTY

ALARIS Medical Systems™, Inc. formerly IVAC® Corporation (hereinafter referred to as "ALARIS Medical Systems") warrants that:

A. Each new instrument is free from defects in material and workmanship under normal use and service for a period of one (1) year from the date of delivery by ALARIS Medical Systems to the original purchaser.

B. Each new accessory is free from defects in material and workmanship under normal use and service for a period of ninety (90) days from the date of delivery by ALARIS Medical Systems to the original purchaser.

If any product requires service during the applicable warranty period, the purchaser should communicate directly with the ALARIS Medical Systems headquarters (San Diego, CA) to determine the appropriate repair facility. Except as provided otherwise in this warranty, repair or replacement will be carried out at ALARIS Medical Systems expense. The product requiring service should be returned promptly, properly packaged and postage prepaid by purchaser. Loss or damage in return shipment to repair facility shall be at purchaser's risk.

In no event shall ALARIS Medical Systems be liable for any incidental, indirect or consequential damages in connection with the purchase or use of any ALARIS Medical Systems product. This warranty shall apply solely to the original purchaser. This warranty shall not apply to any subsequent owner or holder of the product. Furthermore, this warranty shall not apply to, and ALARIS Medical Systems shall not be responsible for, any loss or damage arising in connection with the purchase or use of any ALARIS Medical Systems product which has been;

(a) repaired by anyone other than an authorized ALARIS Medical Systems service representative;

(b) altered in anyway so as to affect, in ALARIS Medical Systems judgement, the product's stability or reliability;

(c) subjected to misuse or negligence or accident, or which has had the product's serial or lot number altered, effaced or removed;

or

(d) improperly maintained or used in any manner other than in accordance with the written instructions furnished by ALARIS Medical Systems.

This warranty is in lieu of all other warranties, express or implied, and all other obligations or liabilities of ALARIS Medical, Systems and ALARIS Medical Systems does not give or grant, directly or indirectly, the authority to any representative or other person to assume on behalf of ALARIS Medical Systems any other liability in connection with the sale or use of ALARIS Medical Systems products.

ALARIS MEDICAL SYSTEMS DISCLAIMS ALL OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR OF FITNESS FOR A PARTICULAR PURPOSE OR APPLICATION.

See packing inserts for international warranty, if applicable.

Foreword

The purpose of this Technical Servcie Manual is to enable personnel who are experienced and trained in the analysis and servicing of microprocessor-controlled instrumentation to maintain, troubleshoot, and repair the MedSystem III® Infusion System.

All KEY NAMES are written in regular type as they appear on the computer keyboard or instrument. Screen messages are written in italics.

This manual contains guidelines for user and patient safety. We suggest you consult the Safety Summary, Appendix H, for general precautions before beginning any maintenance or repair on the instrument.

Specific advisory and cautionary information is contained throughout the manual where applicable.

Contacting ALARIS Medical Systems Technical Support

If you need assistance with the installation or operation of MedSystem III equipment, contact your local ALARIS Medical Systems Account Manager.

If you need technical assistance, call toll free (800) 854-7128 extension 6003.

If you need Customer Service or Parts, call toll free (800) 482-4822.

MAIN TABLE OF CONTENTS

MAIN TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS

Chapter 1
Introduction

1.0 System Introduction

The MedSystem III ™ Infusion System is a small, three-channel, microprocessor-based fluid delivery device capable of controlled and monitored infusion via intravenous, intra-arterial, or subcutaneous routes. Each of the three channels provides the equivalent of an independent infusion device able to pump fluid from syringes, bottles or bags located above or below the level of the instrument. Each channel operates via a disposable infusion cassette. Channels are individually controlled and programmed for infusion tasks. Infusions are monitored to detect occlusions, air in a line, and low power. The electronic and software functions are also monitored using built-in self-tests to help ensure safe operation.

The design and construction of the MedSystem III Infusion System provides the following features:

- Upgradeable software
- Low maintenance, no lubrication
- Calibration through software
- CMOS surface-mount circuitry
- Modular design
- Easy disassembly/reassembly

Maintenance, calibration, and customization features are available through the use of MedSystem III Field Maintenance Software (FMS). This software allows the user to communicate with the infusion system through its RS-232 communications port, using an IBM-PC compatible computer.

1.1 Objectives

The purpose of this manual is to enable qualified service personnel to maintain, troubleshoot, and repair the MedSystem III Infusion System. This manual has been prepared under the presumption that the user is experienced and trained in the analysis and servicing of microprocessor-controlled instrumentation. It is recommended that a factory authorized training program precede any actual disassembly or repair of the instrument.

In light of the state-of-the-art technology used, proprietary nature of the software, and specialized equipment required in the replacement of individual components, it is recommended that troubleshooting and repair be performed only to the module or replaceable part level. Replaceable parts are items that can be replaced with minimal or no unsoldering of circuit components.

It is suggested that a complete overview of all features, functions, and operating procedures be obtained. This can be done by consulting the MedSystem III Directions For Use (DFU) and the MedSystem III Field Maintenance Software Directions for Use, in addition to this Technical Service Manual.

1.2 Using This Manual

This manual includes information on the Model 2860 and Model 2863 pumps. Throughout the manual, if no model number is specified, the information pertains to both models. Where information is specific to one model, that model number is called out.

The Technical Service Manual is specifically structured to facilitate ease of use. Each chapter is clearly defined in the table of contents. Chapter 2 discusses the principles of operation. Chapter 3 discusses functional tests and how to complete them. Chapter 4 provides both routine and annual maintenance procedures. Chapter 5 describes procedures for calibrating the instrument. Chapter 6 discusses troubleshooting, and includes a number of tables to be used as guides during the troubleshooting process. Chapter 7 is a detailed procedure for repairing the instrument.

The appendices included are:

A - Technical Specifications
B - Required Equipment and Supplies
C - Recommended Spare Parts
D - Battery History Log
E - Illustrated Parts List
F - List of Abbreviations and Acronyms
G - Glossary of Terms
H - Safety Summary
I - Schematics

All instructions, special notes, and illustrations are integrated within the text of each chapter to minimize the need to refer to multiple pages during a single operation.

It is suggested that the Safety Summary, Appendix H, be reviewed before beginning any type of service on the instrument.

1.3 New Instrument Checkout

1.3.1 Physical Inspection

- Before unpacking, check the shipping container for damage that may have affected contents. Report any shipping damage to Customer Service.
- Check to ensure that all accessories are included in the package.
- Check for any physical damage to the instrument or accessories. If any is found, report it to Customer Service.

1.3.2 Functional Tests

Refer to your institution's policies for specific requirements regarding inspection and testing of incoming equipment before use.

Recommended functional tests are given in Chapter 3 of this manual.

1.4 Customizing Parameters

Certain MedSystem III operating parameters can be customized using FMS. If customizing is desired, refer to the MedSystem III Directions For Use and the FMS Directions For Use.

1.5 Points of Contact

For parts, disposables, or repair service, telephone:

Customer Service Department
1-800-482-4822

For technical information, assistance with repair, or technical training, telephone:

Product Support Department
1-800-854-7128 extension 6003

TABLE OF CONTENTS

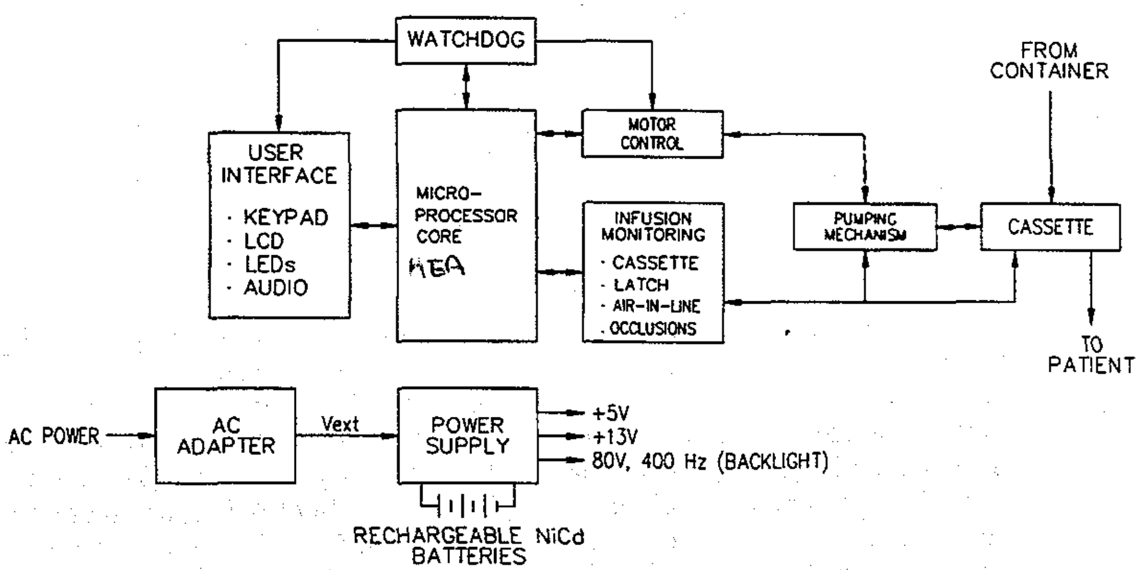
LIST OF FIGURES

Chapter 2
Principles of Operation

2.0 System Overview

The MedSystem III Infusion System provides safe and accurate fluid delivery for a wide range of operating conditions. A block diagram of the overall system is shown in Figure 2-1. A cassette provides a sterile pathway for delivery of fluids and includes sensor interfaces for monitoring infusions. Each channel contains an independent pumping mechanism, motor control system, and infusion monitoring system. Using the keypad and LCD, the operator can program the instrument to monitor infusion. Based on Rate and Volume Remaining, the pumping mechanism is controlled by a microprocessor. Various sensors monitor the infusion to detect proper cassette placement, occlusions, and air in the line. A watchdog circuit ensures that the microprocessor properly executes the software program. If the sensors or watchdog circuit detect a condition that is inappropriate, the infusion is stopped, and the operator is alerted by the red LEDs, an audible tone and a message on the LCD screen. The system is powered by either a rechargeable NiCd battery pack or DC power from the MedSystem AC Adapter. Power consumption is minimized by using complimentary metal oxide semiconductor (CMOS) components and low duty-cycle operation.

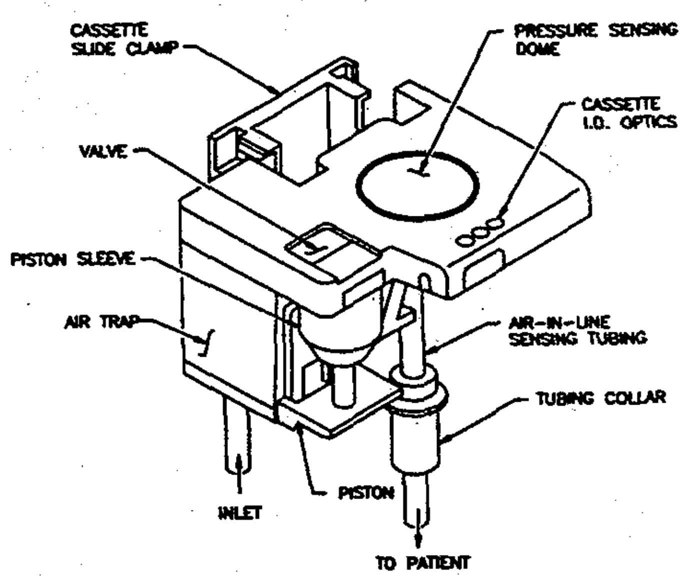
Figure 2-1. Block Diagram of MedSystem III Infusion System



The main functional components of the cassette are shown in Figure 2-2. The cassette contains an elastomeric membrane between two rigid plastic parts. The membrane is exposed for valving and for sensing pressure. The pumping chamber is sealed by a silicone piston sleeve in which the plastic piston is inserted. The piston stroke volume is approximately 80 microliters. Air is sensed in the outlet tubing section between the cassette and tubing collar.

The collar seats in the lower housing of the instrument and holds the tubing securely in the sensor. To detect cassette placement, the optomodule sensor in the chassis of the instrument senses the identification (I.D.) optics of the cassette. The I.D. optics also provide a code that can be used in future applications for identifying different cassette types. The cassette slide clamp latches the cassette to the instrument chassis, engages the slide link to close the pump latch, and automatically occludes the tubing when the cassette is removed from the instrument.

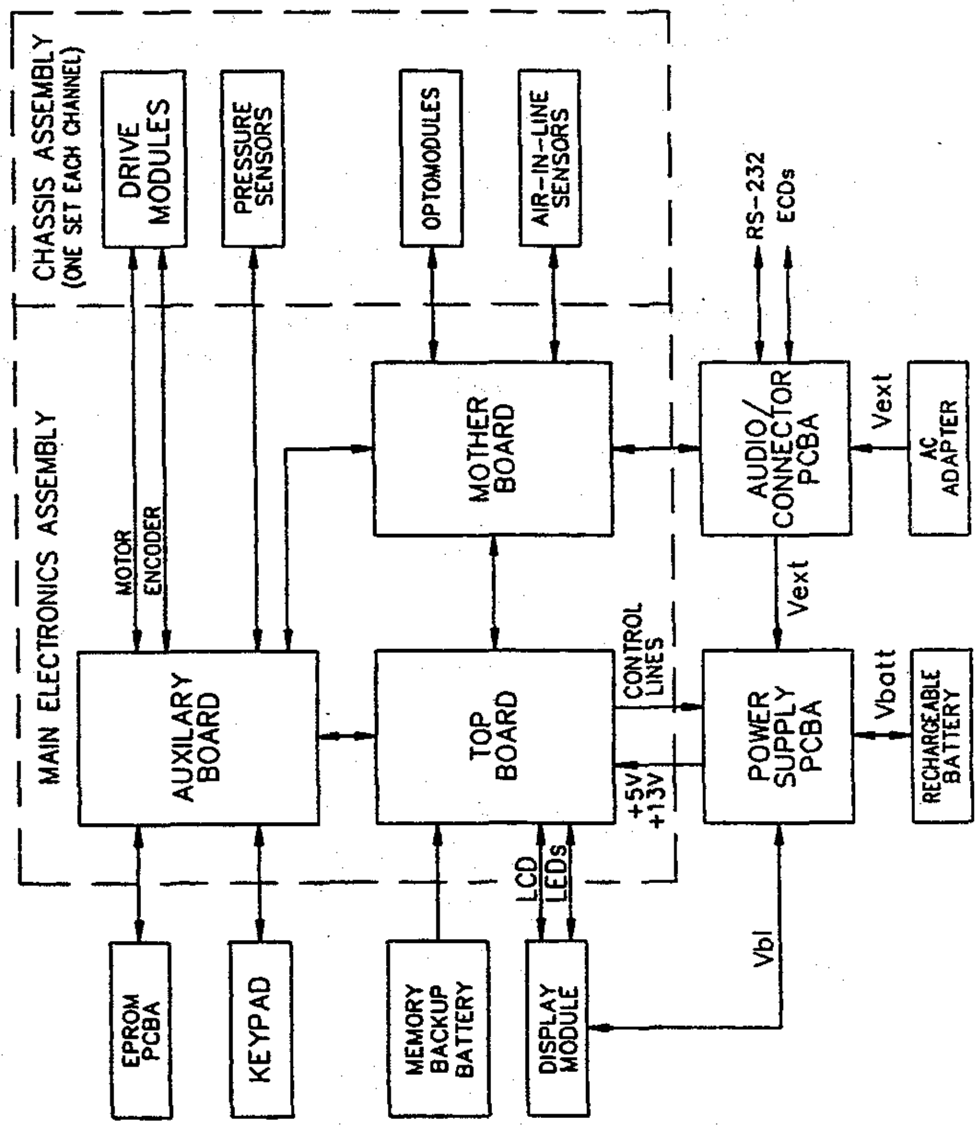
Figure 2-2. Cassette Main Functional Components



The physical configuration of the electronics is shown as a block diagram in Figure 2-3. The microprocessor core, motor control, and watchdog circuits are included in the main electronics assembly (MEA), together with interface circuits for the user interface and infusion monitoring systems. In the Model 2860, the MEA consists of three boards: (1) the mother board, (2) the auxiliary board, and (3) the top board. The power supply printed circuit board assembly (PCBA) and memory backup battery connect to the MEA via the top board. In the Model 2863, the MEA consists of three boards: (1) the mother board, (2) the buffer board, and (3) the top board. The power supply printed circuit board assembly (PCBA) connects to the MEA via the top board. The memory backup battery connects directly to the MEA.

In both models, the drive modules and monitoring sensors mounted on the chassis also connect to the MEA. The audio/connector PCBA and keypad are mounted on the main housing. The audio transducer and connectors for external power, RS-232 communications, and empty container detectors (ECD) are included on the audio/ connector PCBA; however, the ECD option has been discontinued. The display module contains three green and three red LEDs and a super-twist dot matrix LCD with an electroluminescent backlighting panel. The LCD backlighting is powered by an 80V AC inverter on the power supply PCBA.

Figure 2-3. ***Block Diagram of Electronics Physical Configuration (Model 2860 only)***



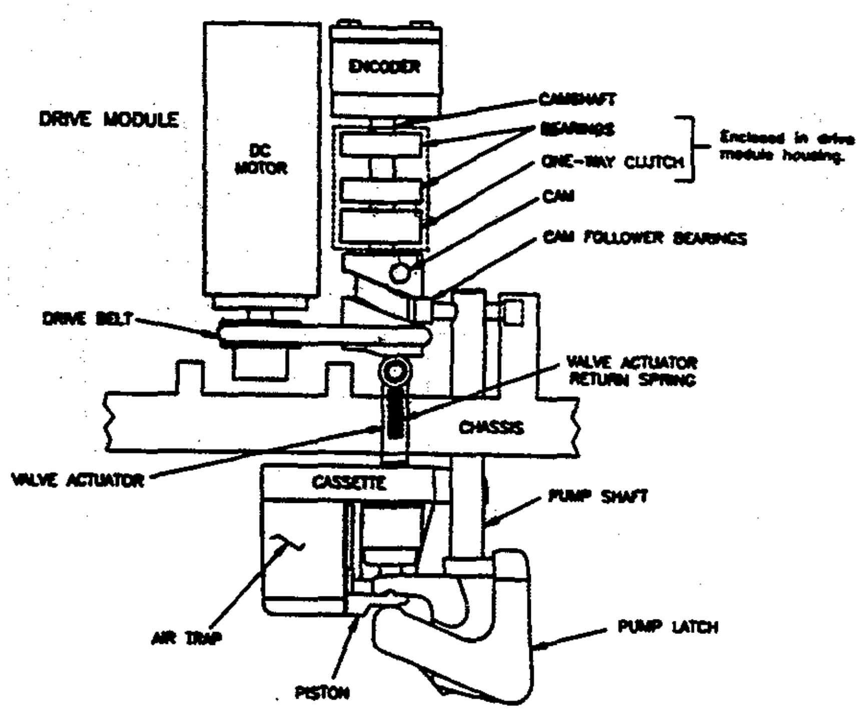
2.1 Fluid Delivery

WARNING

Proper pump latch and valve actuator heights are necessary for correct operation of the instrument. Heights must be adjusted after replacing certain drive components. Removal of drive components or the pump latch should only be performed by trained personnel.

Fluid is delivered to the patient by a reciprocating piston pump powered by a drive module. Each channel has an independent drive module mounted to the chassis. The valves of the pump are formed by actuators in the chassis compressing the elastomeric membrane in the valve area of the cassette. The cassette piston is moved back and forth by the pumping mechanism. A functional diagram of this system is shown in Figure 2-4. The valve actuators and cassette piston are operated by a cam in the drive module. Return springs ensure that the valve actuators follow the cam face properly. The cassette piston is captured by the pump latch which is connected to the pump shaft. Follower bearings attached to the pump shaft engage a track in the side of the cam, causing the pump latch and cassette piston to reciprocate when the cam is rotated. A direct current (DC) motor in the drive module rotates the cam via an elastomeric belt. The drive module housing includes cam shaft bearings for support, and a one-way clutch to prevent backdriving when power is removed from the motor. An encoder on the cam shaft provides position information for controlling fluid delivery.

Figure 2-4. Functional Diagram of Pumping Mechanism



NOTE: Arrangement and scaling of components may be different than actual configuration. This is for clarity.

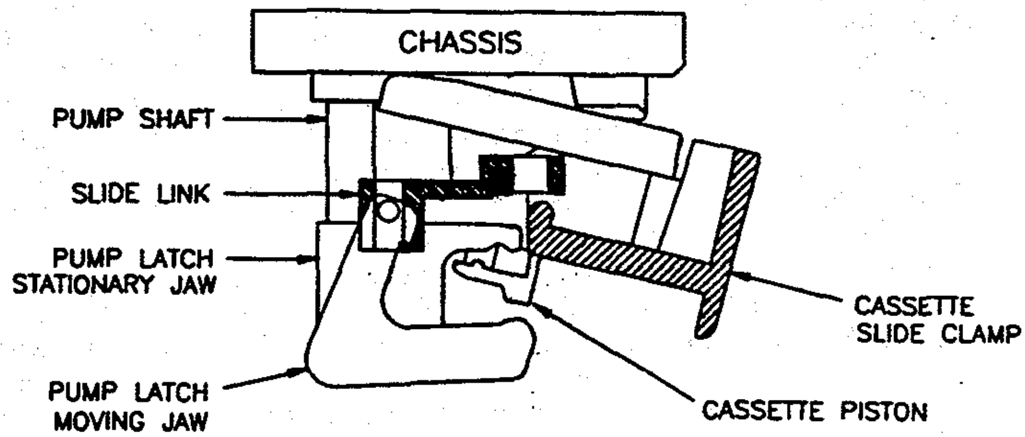
Cassette installation prepares the system for fluid delivery. When the instrument is turned on and a cassette is not installed, the cam is rotated to the "home" position at the beginning of the fill stroke. The home position, which is indicated by a signal from the encoder, allows the pump latch to easily capture the cassette piston. During installation (see Figure 2-5), a tab on the cassette slide clamp engages a slot in the front of the slide link. The movable jaw of the pump latch has a post on the side that engages a slot in the back of the slide link. As the cassette slide clamp is pushed in, the tab pushes the slide link, which, in turn, closes the movable jaw of the pump latch. The cassette piston is now held firmly by the pump latch. Tabs on the slide clamp also engage holders in the chassis to hold the cassette body firmly against the chassis. This forces the valve actuators against the cassette valve area, closing off the fluid pathway. Pushing the cassette slide clamp in toward the chassis also unclamps the patient-side tubing, allowing fluid to be delivered to the patient. The tubing collar is then secured in the air-in-line sensor by the operator. Sensors in the optomodule detect cassette placement and pump latch closure. This, together with the air sensor's detection of fluid, signals that the channel is ready for fluid delivery.

Pumping begins by positioning the valves to fill the pumping chamber. The outlet valve is closed and the inlet valve is opened. The pumping chamber is then filled by retracting the piston (see Figure 2-6A). Once the chamber is filled, the cam closes the inlet valve and opens the outlet valve. Opening and closing of valves is overlapped to ensure the fluid pathway between the container and patient is always closed. Fluid is then delivered by advancing the piston toward the bottom of the chamber (see Figure 2-6B).

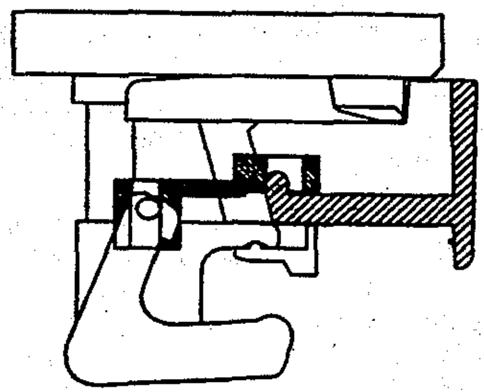
Delivery rate is regulated by varying the duty cycle of the motor, based on feedback from the encoder. An encoder on the cam shaft has several functions, including: (1) sensing whether the pump channel is in the fill stroke or in the delivery stroke, (2) sensing the incremental motion during fluid delivery, and (3) determining the home position. The delivery stroke is divided into 160 increments, which results in a volume resolution of 0.5 microliters. The microprocessor reads a counter that accumulates encoder counts for each channel. The infusion rate, programmed by the user, is converted to required encoder counts. From the required and measured encoder counts, a feedback control algorithm in the software determines the appropriate motor pulse width which is the duration that the motor is turned on.

The controller performs these calculations every three seconds. The calculated pulse width is loaded into a programmable interval timer that controls the drive voltage circuit. A drive voltage of 5V is used for a rate of 275 ml/h or less, and 13V is used for rates greater than 275 ml/h. Valving and pump filling phases are controlled by logic circuits, using an optical encoder signal that marks the delivery stroke. This signal is referred to as DEL. This closed-loop system accurately maintains fluid delivery rate at the programmed value despite the varying loads that are experienced during infusions.

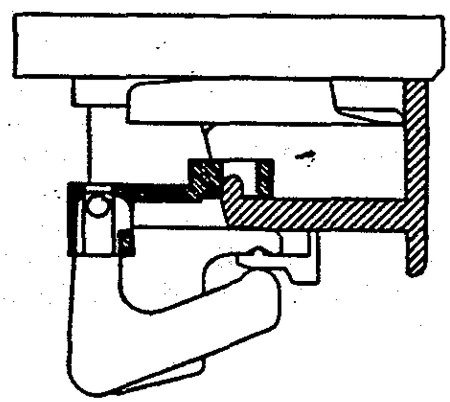
Figure 2-5. Cassette Installation



A. INSERT CASSETTE.

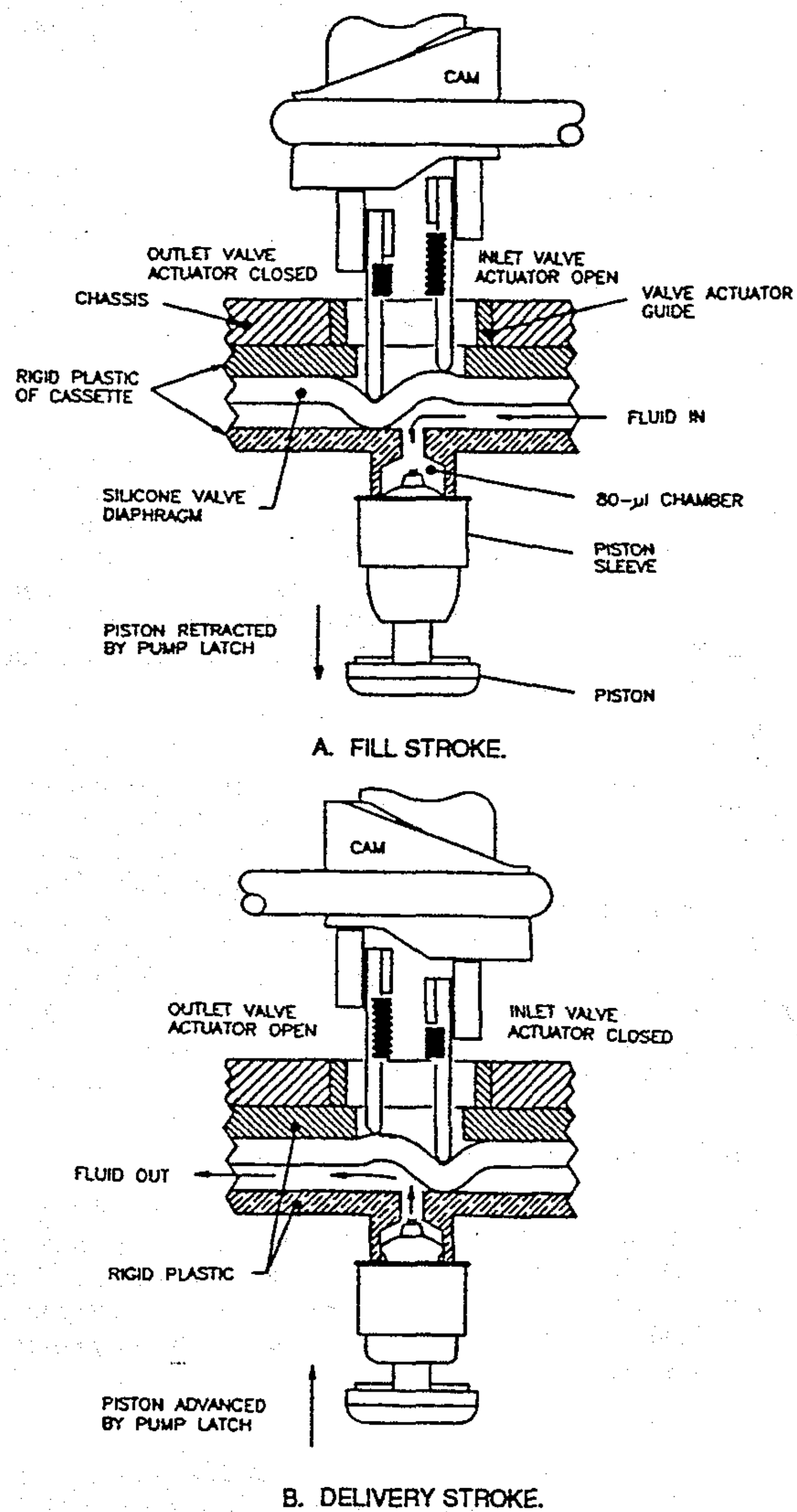


B. POSITION CASSETTE PROPERLY.



C. CASSETTE ENGAGED.

Figure 2-6. Pumping Chamber



2.2 Microprocessor Core

Figures 2-7 and 2-7a are block diagrams of the microprocessor and the components connected to the bus. All components are mounted on the MEA PCBA, unless otherwise noted.

A. Microprocessor

A Z180 8-bit microprocessor system monitors and controls many instrument functions. On-chip functions include a memory management unit, serial communications, two 16-bit programmable reload timers, two direct memory access controllers, and an interrupt controller. In the Model 2860, an on-chip oscillator generates the 6.144 MHz system clock from a 12.288 MHz external crystal. In the Model 2863, an on-chip oscillator generates the 12.288 MHz system clock from a 24.576 MHz external crystal.

B. Address Decoding

The microprocessor bus consists of eight data lines, 20 address lines, and four control lines. In the Model 2860, devices on the microprocessor bus are accessed by the Z180 via logic in the address decode programmable logic device (PLD). This PLD is connected to the address bus and four control lines. In the Model 2863, devices on the microprocessor bus are accessed by the Z180 via logic in the address decode circuits in the two gate arrays. The gate arrays are connected to the address bus and four control lines. In both models, memory and input/output (I/O) maps generate the addresses.

C. Memory

The Z180 can access one megabyte of memory, using the memory management unit. Currently, the instrument uses 256 kilobytes of EPROM for program memory, and 32 kilobytes (Model 2860) or 56 kilobytes (Model 2863) of random access memory (RAM). In the Model 2863, an additional 32 kilobytes of RAM provide dual data paths in hardware to ensure safe operation of software functions. This additional memory is referred to as a shadow RAM. In both models, the EPROMs are mounted on an EPROM board that plugs into the MEA. The RAM is battery-backed to retain information when the instrument is turned off. The integrity of the program and data stored in memory is checked by software which uses a 16-bit cyclical redundancy check (CRC). Corruption of data results in a fault or watchdog alarm.

D. Cyclical Redundancy Check (CRC) (Model 2863 ONLY)

The CRC engines are hardware implementations of an eight-bit parallel CRC-CCITT calculation. The CRC engines are used to detect corruption of system data stored in RAM, to detect errors in messages received over the serial communications link, for the power-on RAM self-test, and to ensure the integrity of the instrument ROM (Read Only Memory) contents. Detecting memory errors (RAM, ROM) result in a watchdog alarm.

E. Input/Output (I/O) Ports

In the Model 2860, three 82C55 integrated circuits (ICs) provide digital input and output lines for interfacing to the microprocessor. Two of the 82C55 ICs are used as output ports, and the third is used as an input port.

In the Model 2863, two gate arrays provide input and output ports for controlling or monitoring digital lines.

F. Real-Time Clock (RTC)

The RTC provides time and date information. This IC is powered by the backup battery when the instrument is turned off.

G. Communications

Serial communication uses the Channel 0 serial port on the microprocessor. An interface IC translates between the microprocessor CMOS levels and RS-232 levels. This interface chip has an on-board charge pump that generates the +10V and -10V required for RS-232 communications. The RS-232 signals are connected to the audio/connector PCBA.

H. Motor Pulse Width Generator

In the Model 2860, pulses for controlling the motors are generated using an 82C54 IC containing three 16-bit programmable counters configured in a one-shot mode.

In the Model 2863, pulses for controlling the motors are generated in Gate Array 1, using three 16-bit programmable counters configured in a one-shot mode. In both models, one independent counter is provided for each pumping channel.

I. Encoder Counters

The encoder provides incremental motion data for determining the volume infused and for controlling motor actuation. In the Model 2860, quadrature encoder output is decoded by a Hewlett-Packard HCTL2000 IC. This integrated circuit includes quadrature decoding and a 12-bit binary up/down counter.

In the Model 2863, Gate Array 1 includes a circuit for quadrature decoding and an 8-bit binary up/down counter to determine the encoder count. There is one circuit for each pumping channel.

J. Analog-to-Digital (A/D) Converter and Multiplexer

Analog signals are sampled by the microprocessor, using an 8-bit A/D converter. This converter contains an eight-channel multiplexer and microprocessor-compatible control logic. A successive approximation method is used by this converter. Conversion time is approximately 100 microseconds. The eight-channel multiplexer is controlled by the microprocessor via the address bus (three bits). In the Model 2860, an external multiplexer circuit provides an additional 32 channels of analog input. In the Model 2863, an external multiplexer circuit provides an additional 24 channels of analog input, for a total of 29 A/D channels.

K. Battery Backup Circuit

When the instrument is turned off, the battery backup circuit maintains the contents of RAM and powers the RTC. Power for battery backup (Vback) is provided by a 2/3 A-size Lithium primary cell. If Vcc falls below 4.6V, a comparator trips, disabling chip-selects to the RAM and RTC, which prevents corruption. An ICL7673 automatic battery-backup switch connects either Vcc or Vback (depending on which voltage is highest) to the RAM and RTC power pin. The output of the ICL7673 is referred to as Vbb.

Figure 2-7. Block Diagram of Microprocessor and Components Connected to the Bus (Model 2860)

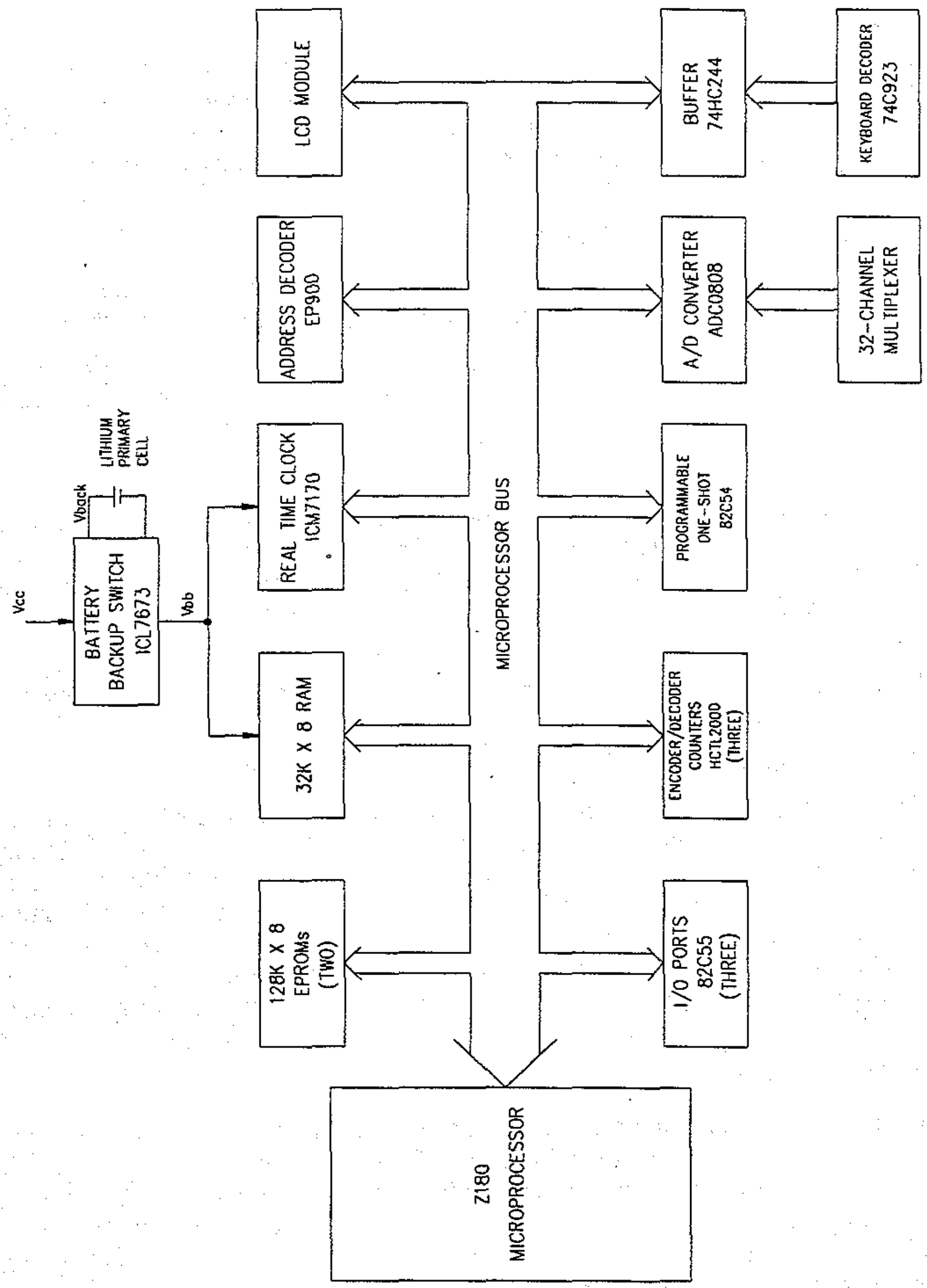
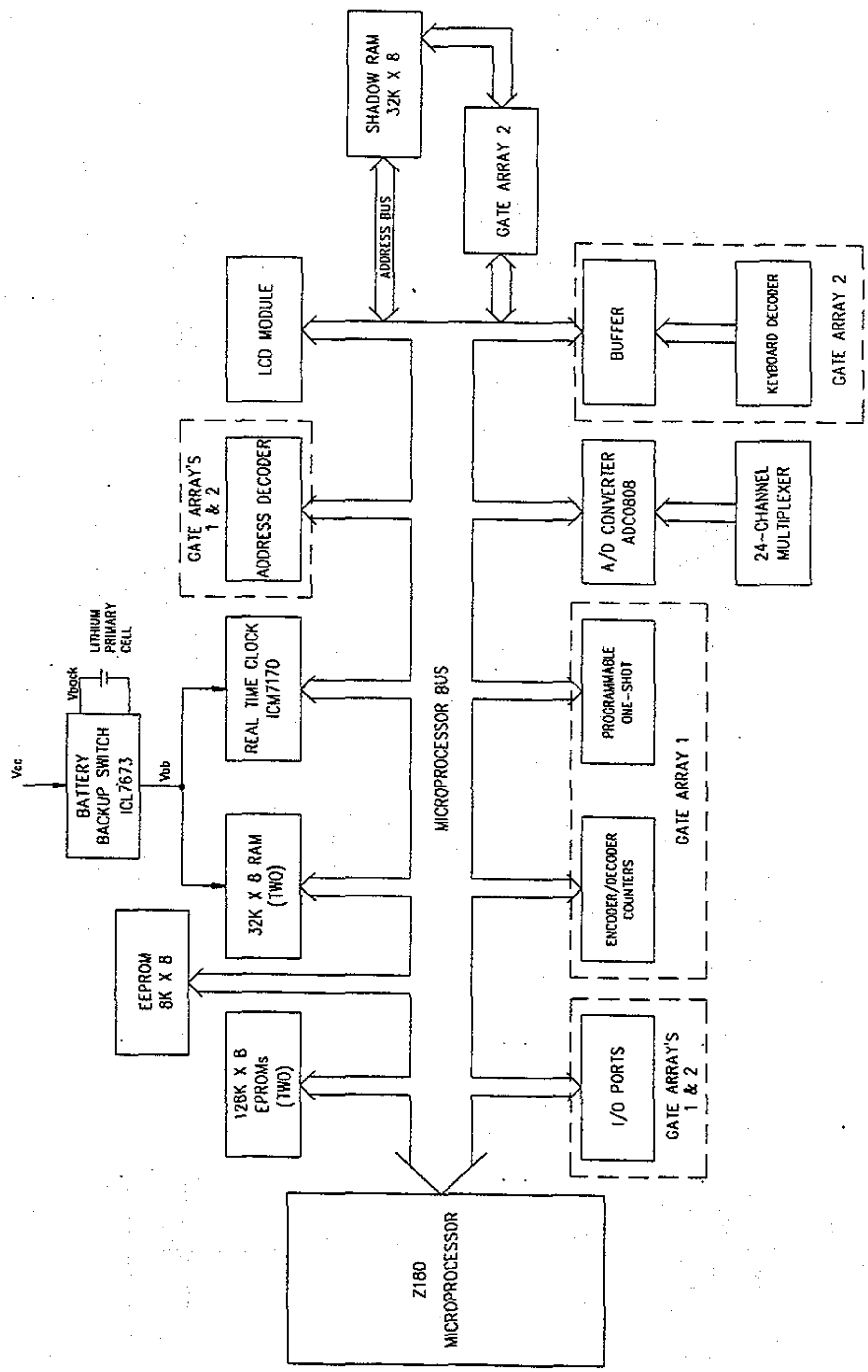


Figure 2-7a. Block Diagram of Microprocessor and Components Connected to the Bus (Model 2863)



2.3 Watchdog

The watchdog circuit is an independent monitor that ensures safe operation of the microprocessor. The circuit consists of a one-shot, an oscillator/ripple counter, and logic circuitry (see Figures 2-8 and 2-8a).

Figure 2-8. Block Diagram of Watchdog Circuit (Model 2860)

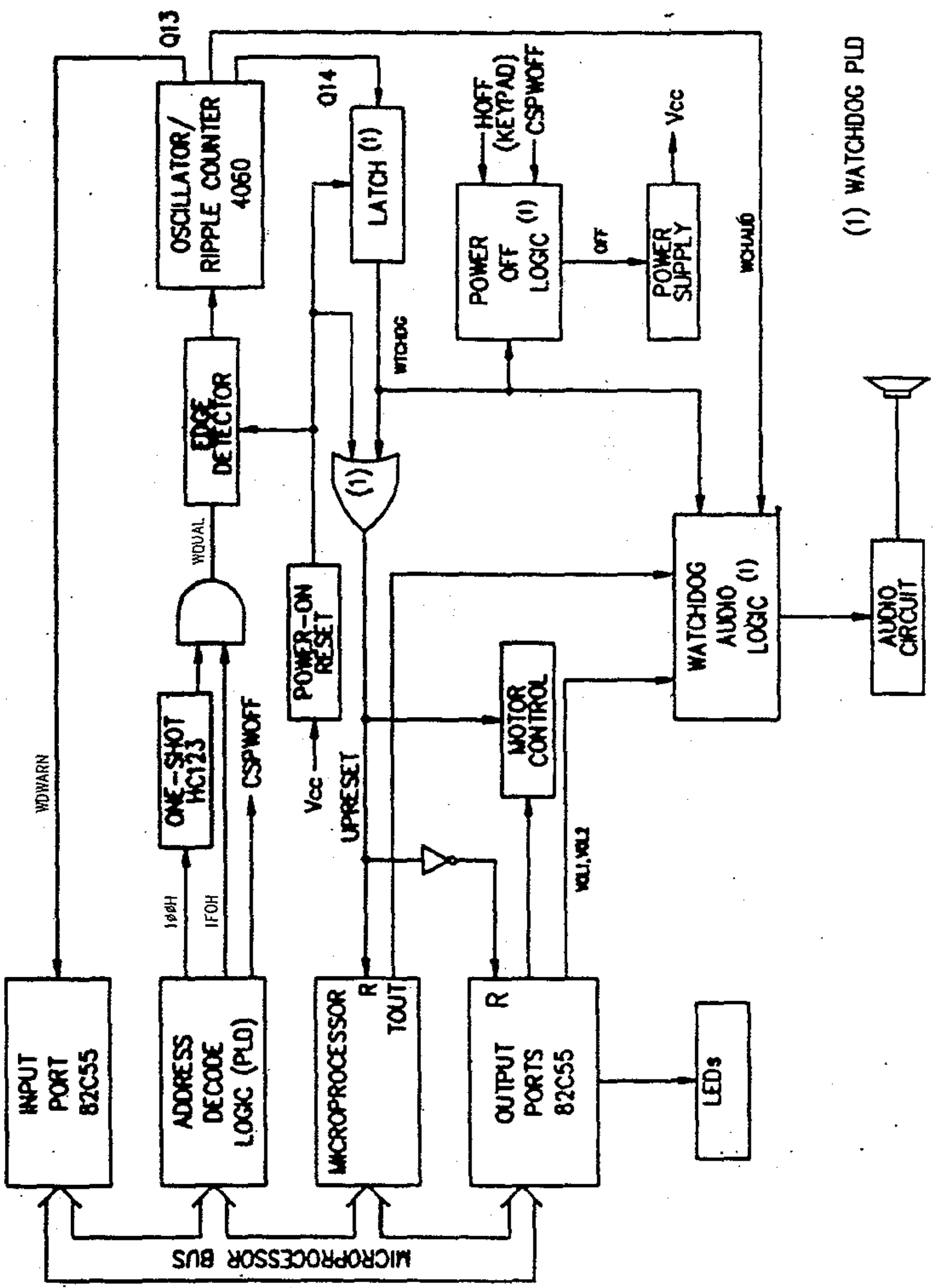
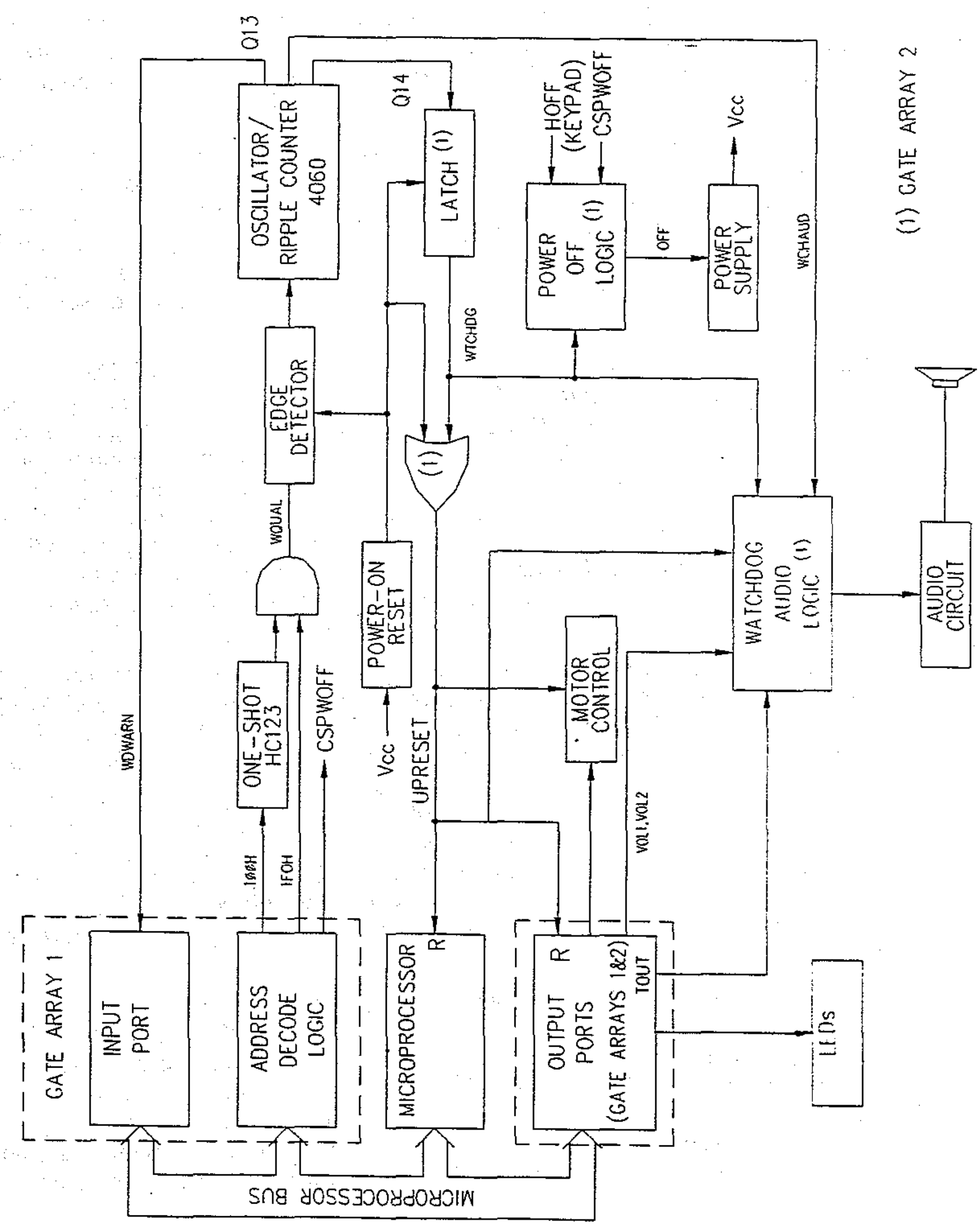


Figure 2-8a. Block Diagram of Watchdog Circuit (Model 2863)



In the Model 2863, the watchdog circuit is completely tested during power-on. During the watchdog circuit test, the counter is not reset and Q14 will go high, generating a non-maskable interrupt (NMI) to the microprocessor. This shuts off power to the motors and holds the system in reset. Logic in Gate Array 2 allows

the watchdog to be reset **once** after the power-on test. After the first reset, if the counter is not periodically reset, the Q14 output will go high again. This will generate a second NMI to the microprocessor, which shuts off power to the motors and holds the system in reset. The watchdog circuit cannot be reset a second time; therefore, the only action possible is to turn off the instrument.

In both models, the power-on reset circuit initializes elements of this system during power-up. If the software fails to reset the counter, a special alarm is triggered. In the Model 2860, logic holds the microprocessor in reset, disables the motors, produces a constant audio tone, and turns on the keypad LEDs. In the Model 2863, logic generates an NMI to the microprocessor and holds the output ports in reset, disables the motors, produces a constant audio tone, and turns on all the keypad LEDs.

The WQUAL signal is generated by the software to reset the counter. Three actions must occur to generate the WQUAL signal. First, the software must detect a high level on the signal WDWARN to ensure the counter is operating at the correct frequency. If this signal is not correct, then either an instrument fault (event code 256) or watchdog alarm occurs. Next, the software writes to I/O address 100H via the address decoding logic, which generates a trigger pulse for the one-shot. The output of the one-shot goes high for 90 microseconds, during which time the software must write to I/O address 1FFH. The combination of these two actions generates the signal WQUAL. The rising edge of the WQUAL signal resets the counter.

Failure to reset the counter circuit results in holding the system in reset. The counter reset input must be pulsed high once every 100 milliseconds (Model 2860) or 200 milliseconds (Model 2863), otherwise, the output line Q14 oscillates. The rising edge of Q14 causes the output of the latch (WTCHDG) to go high, generating the system reset signal and producing a watchdog alarm. In the Model 2860, the UPRESET line holds the output ports (82C55) in reset, blanks the LCD, turns on all six of the keypad LEDs, and shuts off the power to the motors. In the Model 2863, the UPRESET line holds some of the output ports in reset, dims the LCD, turns on all six of the front panel LEDs, and shuts off power to the motors. In both models, the only action that can be performed by the operator is to turn off the instrument.

The power-off logic circuit can power-down the instrument under either normal or watchdog conditions. During normal operation when an ON/OFF keypress is detected, software generates the signal CSPWROFF via the address decoding logic, asserting the OFF signal high. This signal disconnects the 5V and 13V converters on the power supply from the MEA. After the watchdog circuit has triggered, the microprocessor cannot generate the CSPWROFF signal. In this case, the WTCHDG input to the power-off logic is high; and, the HOFF signal from the keypad controls power-down.

During a watchdog alarm, the instrument produces a continuous audio tone. Under normal operation, audio volume and frequency are microprocessor controlled (VOL1, VOL2, and TOUT). When the watchdog circuit triggers, logic circuits in the watchdog PLD (Model 2860) or in Gate Array 2 (Model 2863) produce a continuous audio tone at the highest volume. The watchdog tone WCHAUD signal is generated by the ripple counter.

2.4 User Interface

A. Keypad Circuit

The keypad circuit provides controls for operating the instrument. The keypad control switches consist of a separate ON/OFF key and a matrix of 10 function keys. When a key is pressed, the interface circuit generates an interrupt (KBDINT*) to the microprocessor which then reads an input port to determine whether a function key or the ON/OFF key was pressed (see Figures 2-9 and 2-9a). The interrupts are cleared by the microprocessor through output port KBDINTCLR.

The ON/OFF key is separate from the function key matrix. Debouncing is performed by a resistor capacitor (RC) time constant and Schmitt trigger. An interrupt is generated from the debounced signal, HOFF, by latching the output of an edge detector. The HOFF also goes to the watchdog power-off logic and an input port.

The function key switch matrix is connected to a 74C923 keyboard decoder in the Model 2860, and a keyboard decoder in Gate Array 2 in the Model 2863 which debounces key presses, decodes the key matrix, and informs the microprocessor of a keypress. During a keypress, the KBDDA line goes high for the duration of the keypress. Interrupts are generated from the leading and trailing edges of KBDDA. The KBDDA is sampled via an input port to determine whether the key is depressed or released. The location of the keypress in the matrix is communicated from the decoder to the microprocessor, using five (Model 2860) or four (Model 2863) bits of the data bus.

A foil layer in the keypad provides shielding against electrostatic discharges. A tab from the shield is attached to the conductive coating on the inside of the main housing, using conductive tape.

B. Liquid Crystal Display (LCD)

A "super-twist" transflective LCD is mounted on a separate PCBA known as the Display Module. The Display Module includes display drivers, a display controller, and the necessary RAM to control the LCD. The LCD communicates to the microprocessor via the bus. The LCD requires a negative voltage (-Vlcd) to change the orientation of the liquid crystals. This voltage is supplied by the contrast control circuit. The LCD is backlit by an electroluminescent (EL) panel driven from an AC supply on the power supply PCBA.

C. Liquid Crystal Display Contrast

The LCD contrast is adjusted by varying the negative supply voltage, Vlcd. A block diagram of this circuit is shown in Figure 2-10. An ICL7660 generates a -5V power source which is converted to Vlcd by the SCI7661. A low level on the output port LCD ON*/OFF turns on the ICL7660. The output of the SCI7661 is connected to a resistor string.

Different string outputs are connected by a multiplexer to the feedback pin of the SCI7661. This circuit provides regulated negative supply voltage in the range of -11V to -14V. The resistor string tap is selected by software through the use of the VIEW (Model 2860) or CNTRST (Model 2863) softkey, using three output ports (LCDCTRST1, LCDCTRST2, and LCDCTRST3). Seven contrast levels are provided by the three control lines.

D. Infuse and Alarm LEDs

The infuse (green) and alarm (red) LEDs that appear in the upper corners of the Channel Select keys (A, B, and C) are controlled by software, using output ports. In both models, the LED is turned on if an output port is set high. Self-tests of the LEDs are performed by using the A/D converter to measure the voltage drop across the LED.

Figure 2-9. Block Diagram of Keypad Circuit (Model 2860)

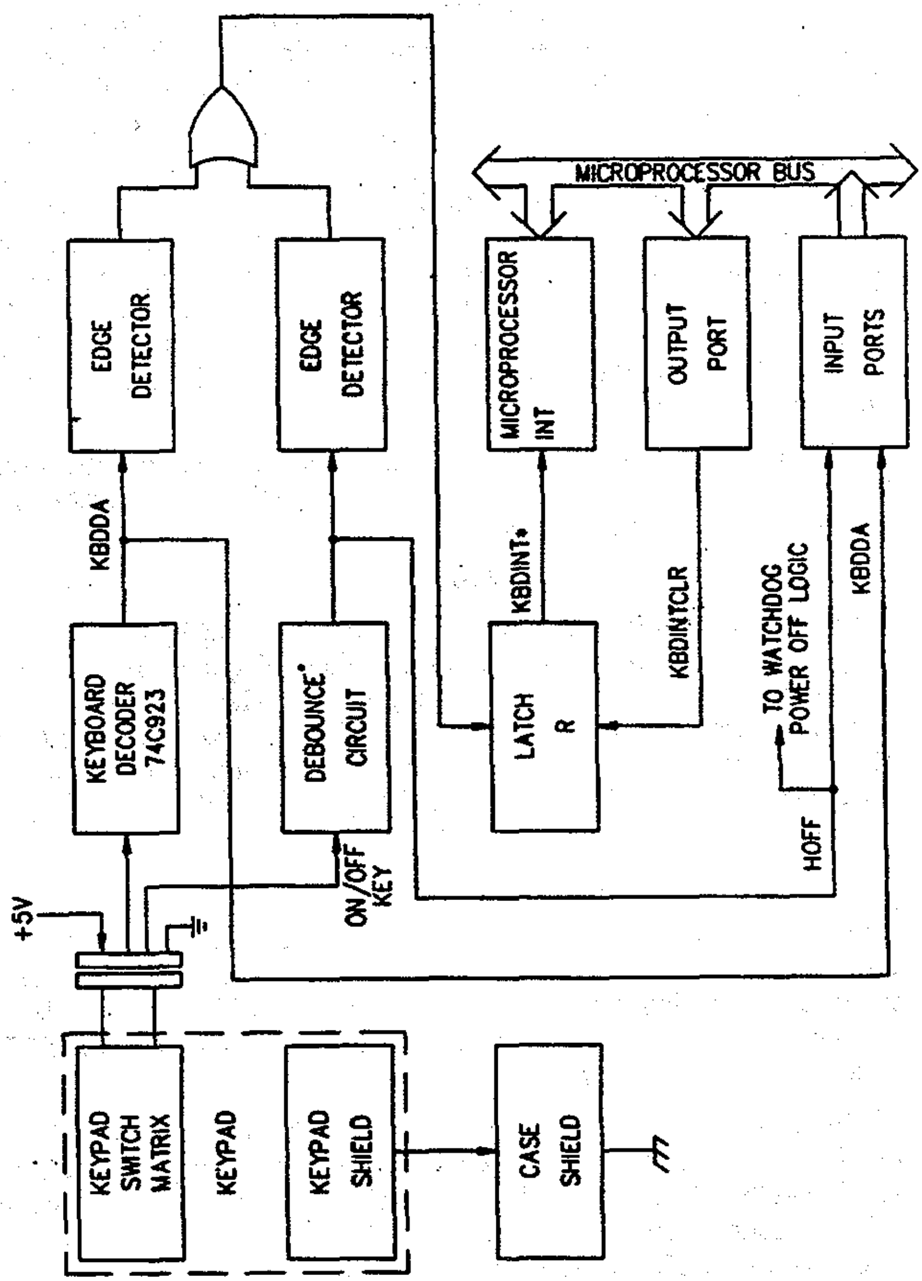


Figure 2-9a. Block Diagram of Keypad Circuit (Model 2863)

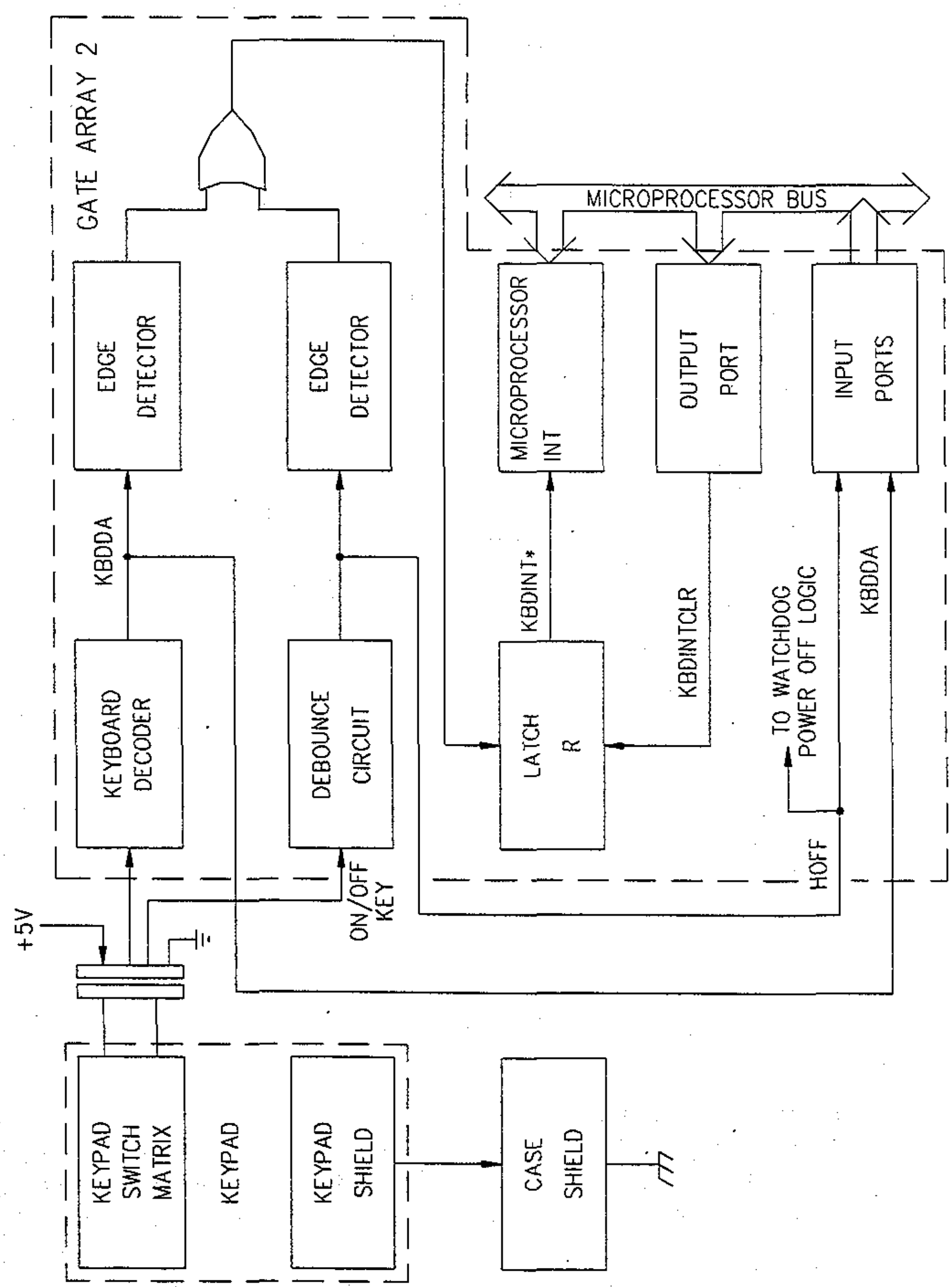
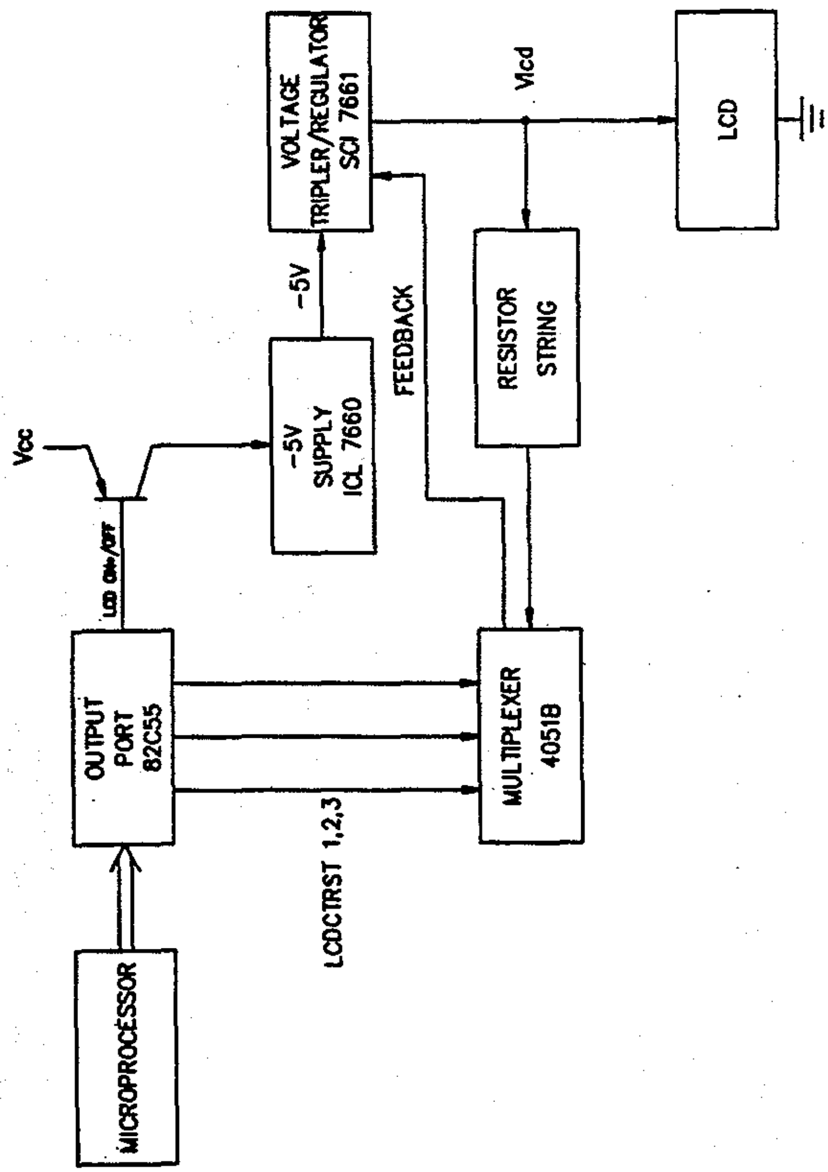


Figure 2-10. Block Diagram of LCD Contrast Control Supply Voltage Circuitry



E. Audio

Audio output is generated by a speaker on the audio/connector PCBA via the circuit shown in Figures 2-11 and 2-11a. The volume levels are controlled by the microprocessor, using output ports VOL1 and VOL2. The audio tones are generated using a programmable reload timer in the microprocessor (Model 2860) or in Gate Array 1 (Model 2863). Software generates different frequencies by loading a count into the timer control registers. The timer output, TOUT, is connected to the watchdog audio logic in the watchdog PLD (Model 2860) or in Gate Array 2 (Model 2863). Different amplitude drive signals provide volume control. The drive signal amplitude is determined by a multiplexer which selects a resistor string tap. This, in turn, applies different levels of DC voltage to the speaker drive transistor.

Figure 2-11. ***Block Diagram of Audio Generator Circuit (Model 2860)***

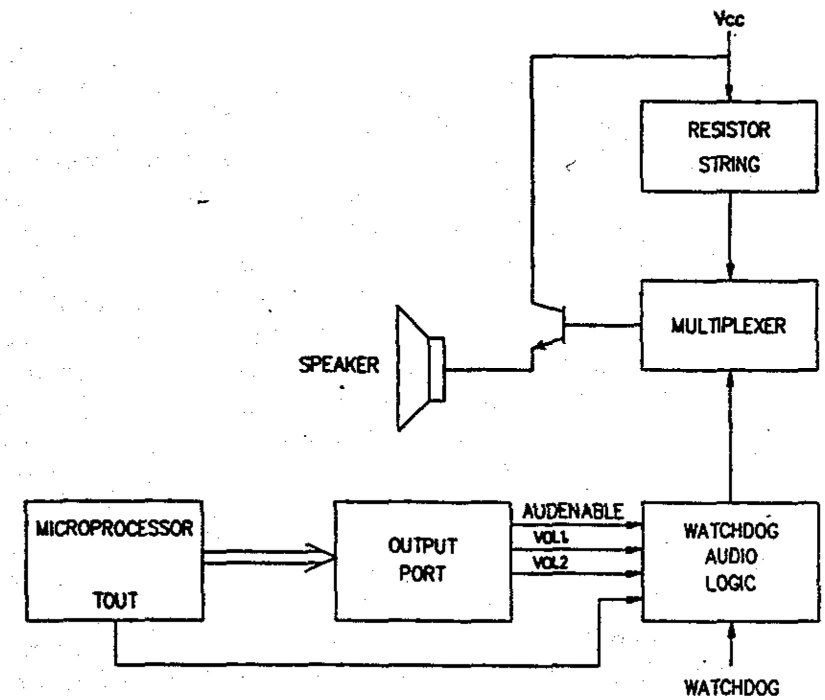
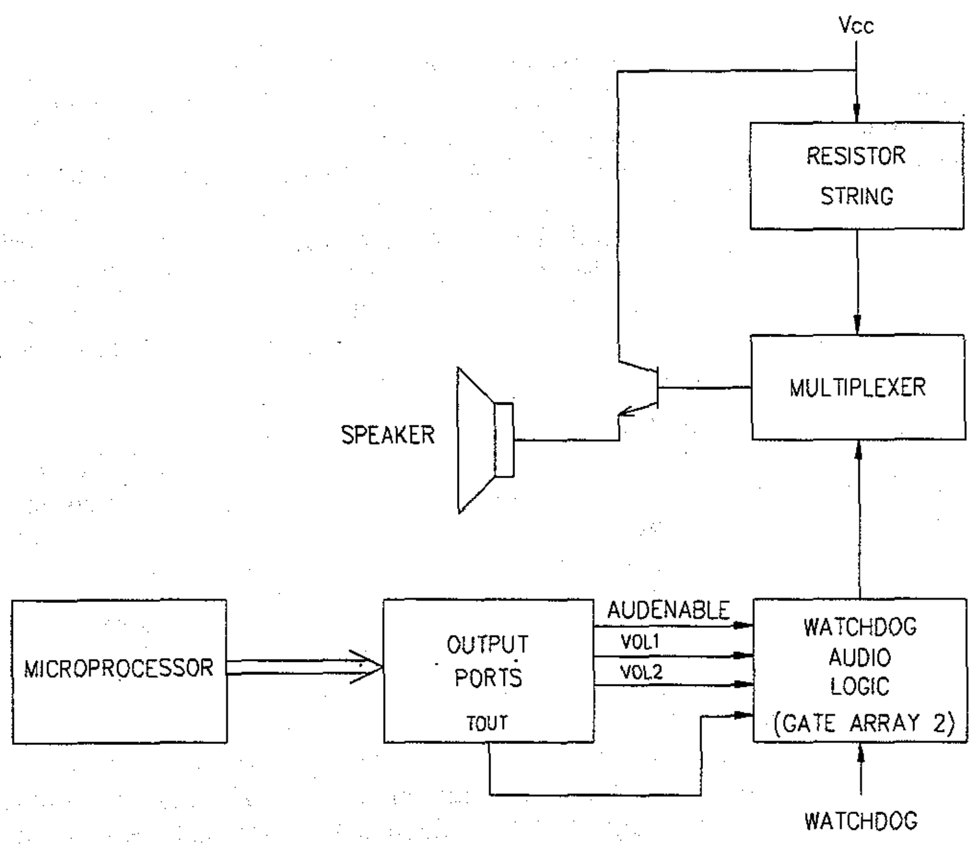


Figure 2-11a. ***Block Diagram of Audio Generator Circuit (Model 2863)***



2.5 Motor Control System

A. System Overview

Infusion rate is regulated using a feedback system to control the motor (see Figures 2-12 and 2-12a). The encoder provides one signal (DEL) that indicates the pumping cycle (e.g., delivery) and two signals (A and B) to determine incremental motion. The A and B signals are derived from a single LED source and a pair of phototransistors that are physically offset. This provides for a higher encoder resolution than is obtainable with a single phototransistor. Since the phototransistors are offset, the resultant waveforms for the A and B tracks are 90 degrees out of phase (see Figure 2-13). This allows for quadrature decoding, a method for determining direction of motion by comparing two out-of-phase signals. The A and B signals are decoded and counted using an HCTL2000 IC in the Model 2860, or by circuits in gate array 1 in the Model 2863; both are connected to the microprocessor bus. Every three seconds, a feedback control algorithm in software determines the appropriate motor pulse width from the difference between the required and the measured number of encoder counts. The calculated pulse width is loaded into an 82C54 programmable interval timer in the Model 2860, or into a programmable one-shot circuit in Gate Array 1 in the Model 2863. In the Model 2860, logic circuits in the motor control PLD control the action of the drive circuits. In the Model 2863, the logic circuits in Gate Array 1 control the action of the drive circuits. In both models, the drive circuits also include redundant shutoff transistors to prevent faults from causing motor run-away. A drive voltage of 5V is used for rates of 275 ml/h or less, and 13V is used for rates greater than 275 ml/h.

B. Encoder

The encoder mounted on the cam shaft provides three signals (DEL, A, and B) for controlling the motors. The following are determined from these three signals: (1) home position, (2) DEL marker, indicating the pump delivery stroke, (3) 160 incremental counts during DEL, and (4) a brake marker at the end of refilling. The home position, which is at the beginning of the fill stroke, is used to locate the drive for ease of cassette installation and for the fluid-side occlusion detection. Homing is only performed when a cassette is not present (refer to Operating Instructions for details). The DEL marker and incremental counts are used to control fluid delivery. At low infusion rates, the brake marker stops the mechanism near the beginning of the delivery stroke.

The shaft encoder consists of a PCBA permanently mounted on the drive module housing and a slotted disk mounted to the cam shaft. The PCBA includes an LED light source, slit plates, three phototransistor detectors, and three amplifiers. The slotted disc is located between the slit plates which collimate light rays to the desired detector (see Figure 2-14).

Since the encoder LED requires approximately 20 milliamps to operate, it is strobed by logic in a PLD (Model 2860) or in Gate Array 1 (Model 2863) to save power. A current regulator circuit is in series with the LED to minimize Vcc and temperature variations. With the LED on, light shining through an opening on the slotted disc causes the phototransistors to conduct. The output of the phototransistors is buffered and latched. The latches are on the MEA. Hysteresis is provided on the DEL signal to prevent signal jitter, in the event that the encoder disc stops on

the edge of the DEL track.

The nominal timing of the latched encoder signals is shown in Figure 2-13. The first rising edge of the A signal produced by the first quadrature slot is defined as zero degrees or top dead center (TDC). This edge is aligned very accurately to the cam such that it signals the beginning of a pump stroke. The rising edge of DEL marker occurs about 12 degrees before TDC and is used as a brake marker. The falling edge of DEL occurs nominally coincident with the falling edge of the last slot of the B signal. The home marker is the logical combination of A and the complement of DEL (DEL*) implemented in the motor control logic PLD in the Model 2860, or in Gate Array 1 in the Model 2863.

> ***WARNING***
>
> *The alignment of the cam to the encoder is critical for proper fluid delivery; therefore, do not repair defective modules. Defective modules must be replaced.*

Encoder self-test is performed by software. The DEL marker is polled every 50 milliseconds via an I/O port. The software ensures that the encoder counts properly while pumping. If an abnormal condition is detected, a channel fault alarm occurs.

C. Pulse Width Generation

In the Model 2860, the motor pulse width generated by the feedback control algorithm is implemented using an 82C54 programmable interval timer that is operated in a hardware-triggered, programmable, one-shot mode. When a pulse width count is loaded from the microprocessor, the output goes high, and the timer decrements during the DEL cycle. When the counter decrements to zero, the output goes low. This turns off the motor. The counter is not decremented during the DEL* filling cycle. This is accomplished by gating the clock input with the DEL signal, using logic in the motor control PLD (Model 2860) or in the motor control circuits of Gate Array 1 (Model 2863).

In the Model 2863, the motor pulse width generated by the feedback control algorithm is implemented using a programmable one-shot. When a pulse width count is loaded from the microprocessor, the output goes low, and the timer decrements during the DEL cycle. When the counter decrements to zero, the output goes high. This turns off the motor. The counter is not decremented during the DEL* filling cycle. This is accomplished by gating the one-shot clock input with the DEL signal, using logic in the motor control circuits of Gate Array 1.

D. Motor Control Logic

Logic incorporated in a PLD (Model 2860) or in Gate Array 1 (Model 2863) is used to control the motor drive circuitry. The inputs to the control logic are the 82C54 pulse width generator (Model 2860) or the programmable one-shot pulse width generator (Model 2863), the encoder DEL and A track signals, and several output port control lines (Figures 2-12 and 2-12a). This logic performs several functions which include controlling the motor drive voltage, decrementing the counter to generate the motor pulse width, turning on the brake transistor, and homing the mechanism.

E. Motor Drive Circuitry

The motor drive circuits (Figures 2-15 and 2-15a) control the application of power to the motor. During an infusion, the pulse width, modified by the motor control logic, is applied to the gates of FETs connected to the motor. One FET is used to apply 5V of power to the motors for low infusion rates, and a second FET applies 13V to the motors for high rates. A level shifter converts the motor control logic signal to a voltage required to control the 13V FET. Whenever the motor is not being operated, it is shorted by the brake FET.

Figure 2-12. Block Diagram of Motor Control System (Model 2860)

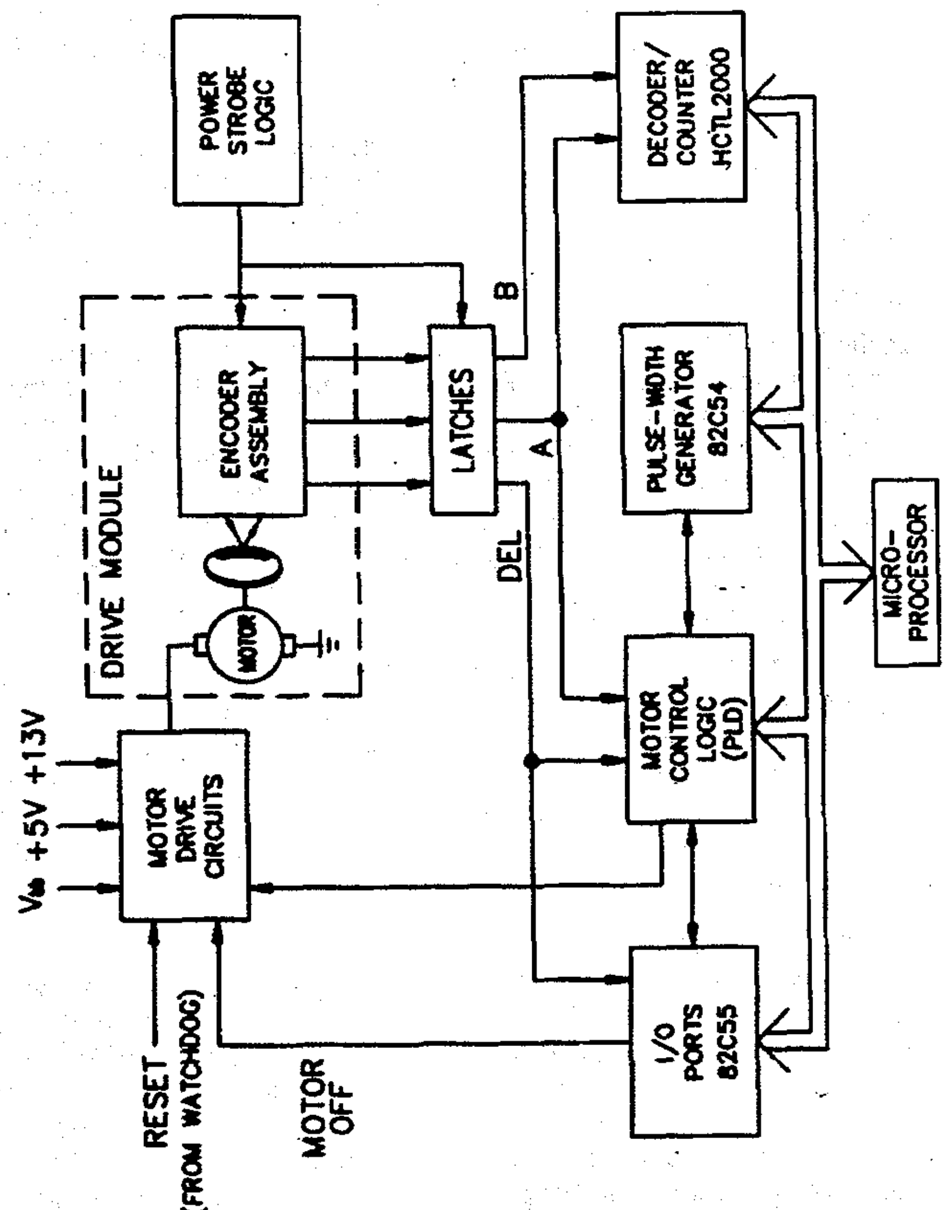


Figure 2-12a. Block Diagram of Motor Control System (Model 2863)

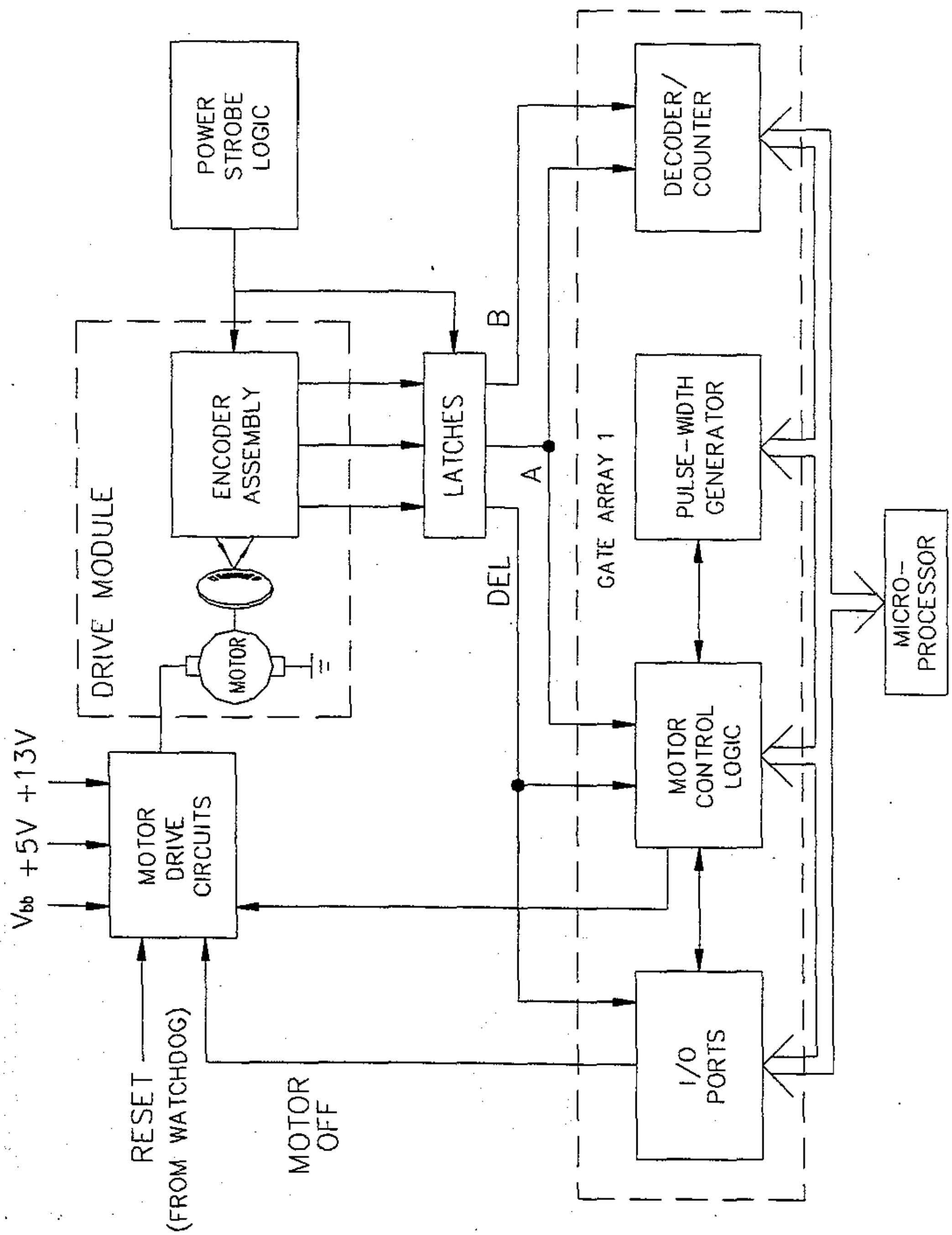


Figure 2-13. ***Nominal Timing of Latched Encoder Signals***

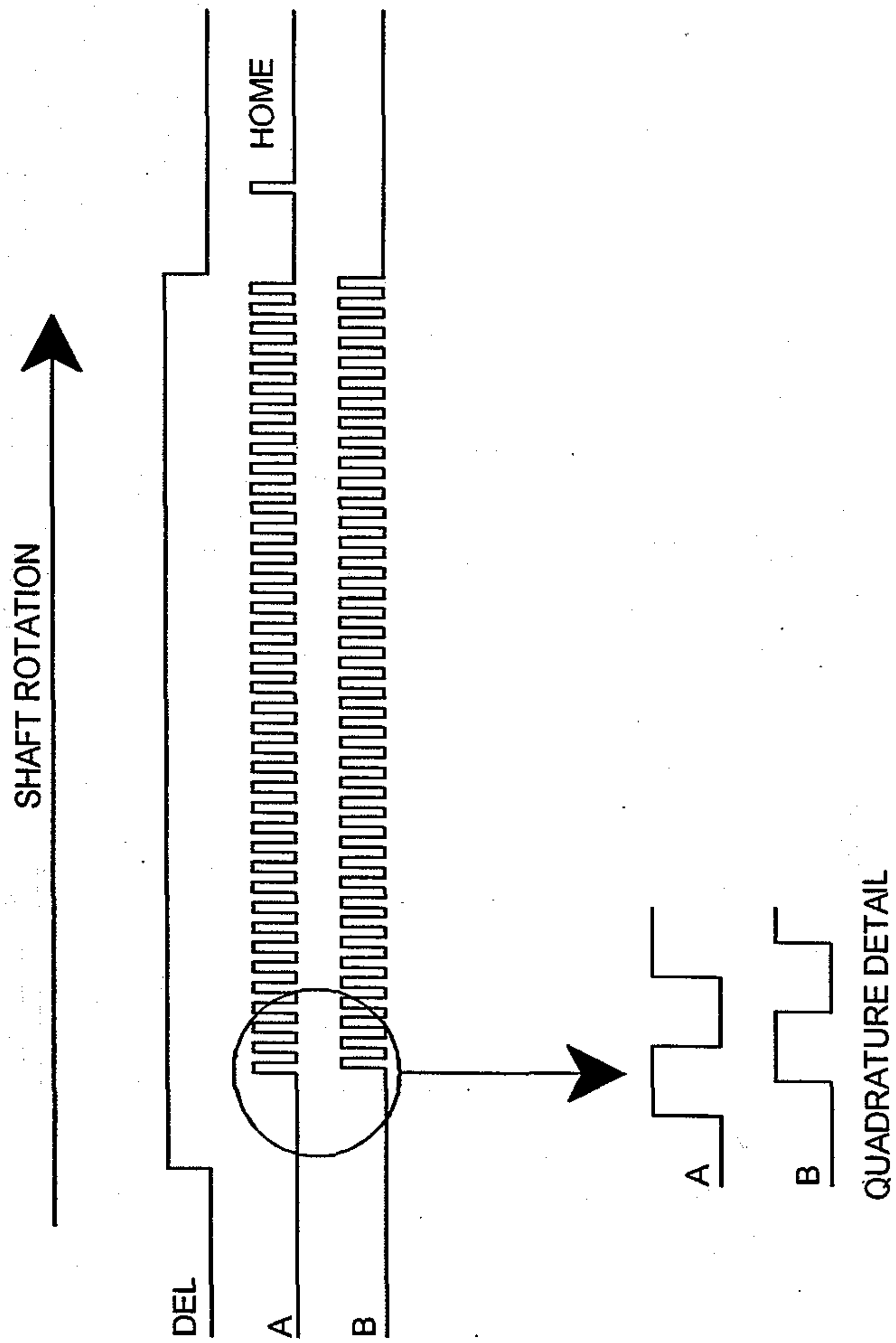


Figure 2-14. Encoder Interface PCBA

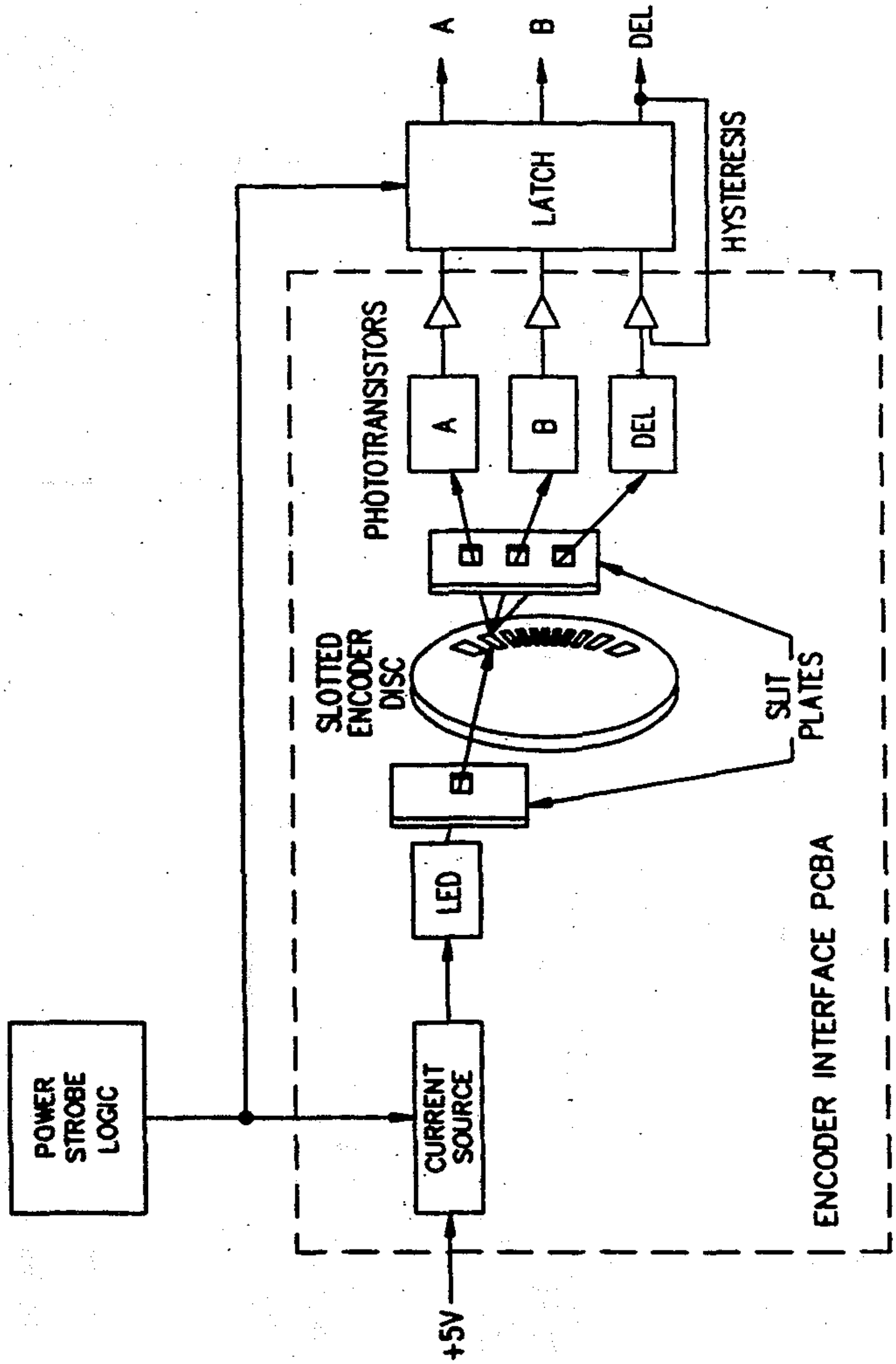


Figure 2-15. Block Diagram of Motor Drive Circuit (Model 2860)

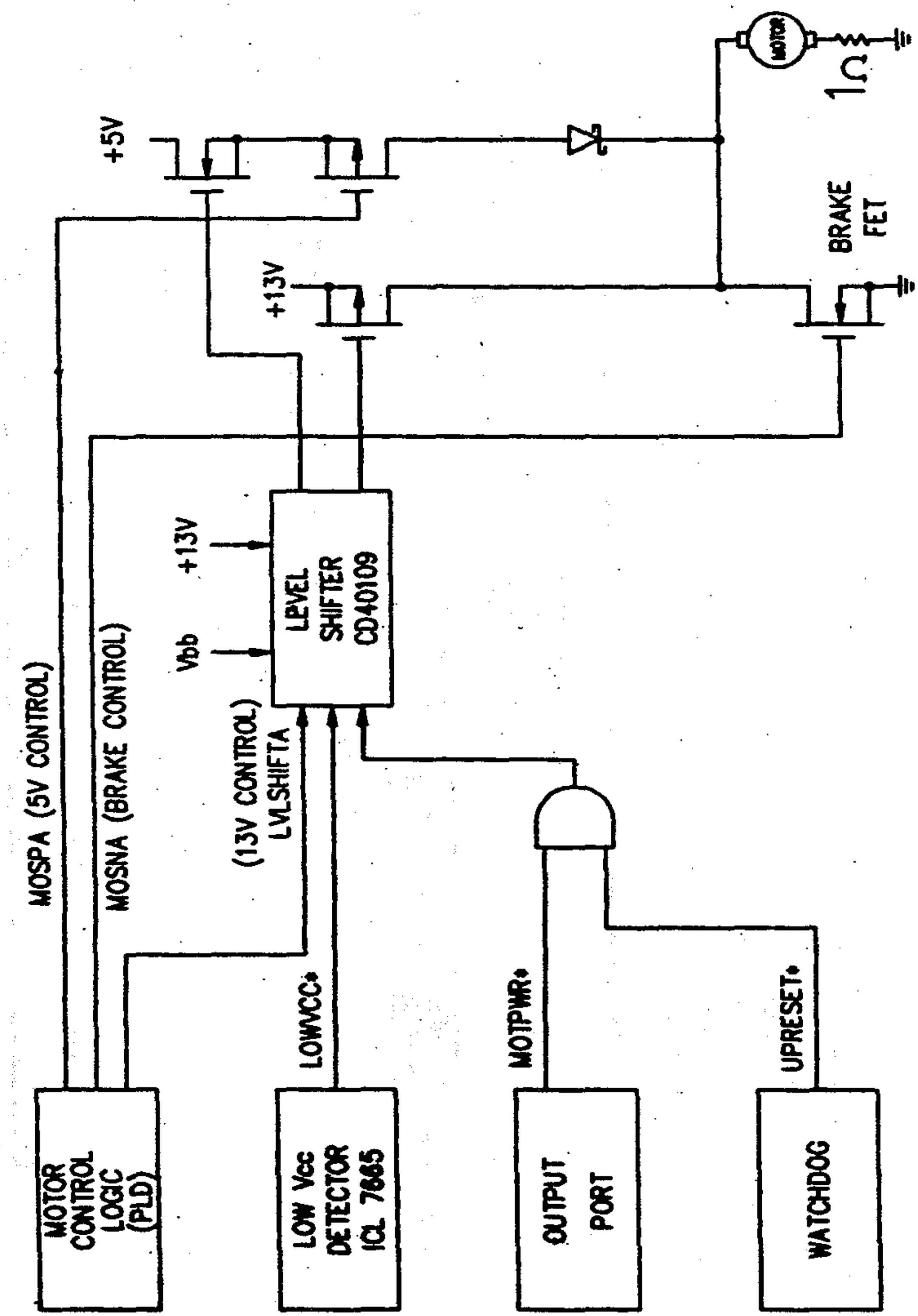
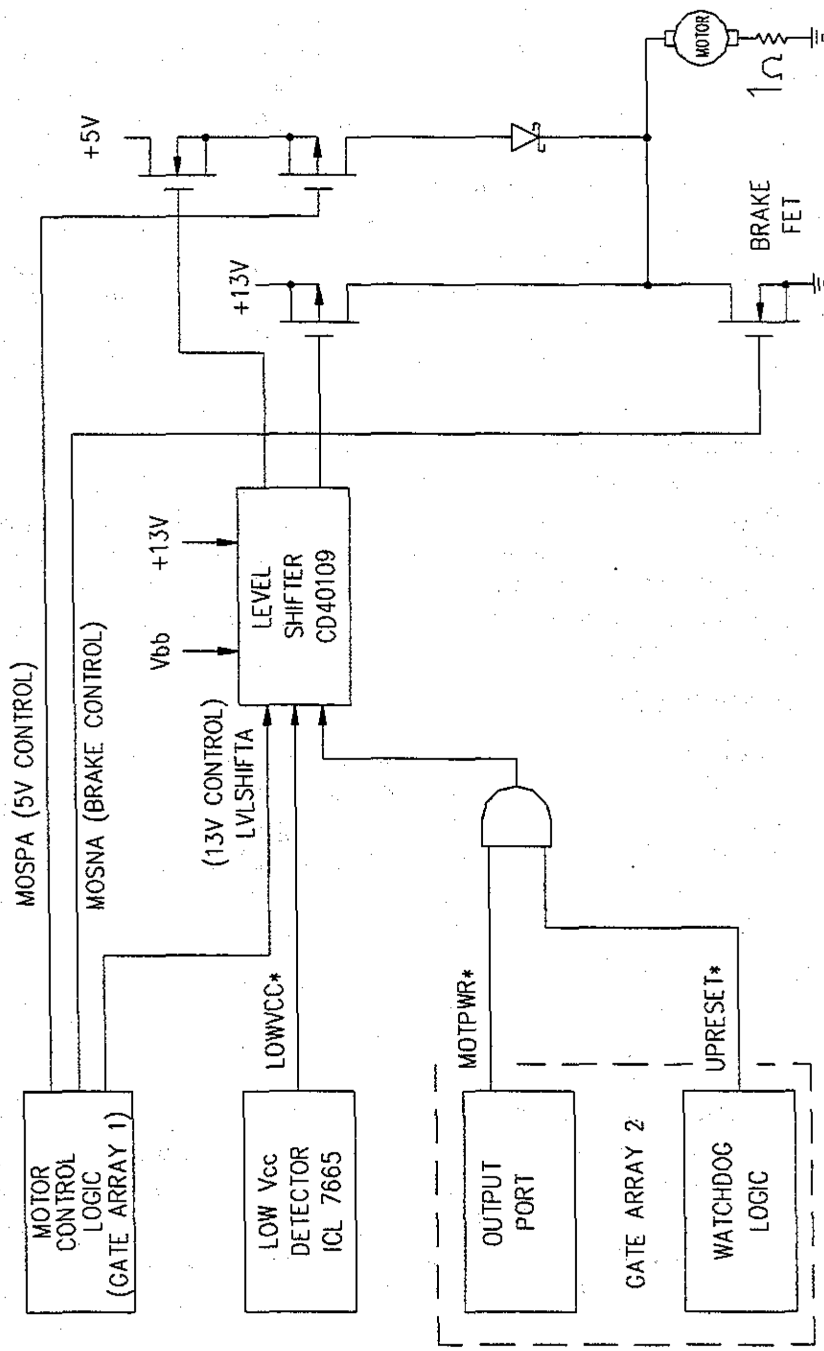


Figure 2-15a. ***Block Diagram of Motor Drive Circuit (Model 2863)***



2.6 Infusion Monitoring

A. Cassette and Latch Sensing

Before an infusion can be started, a cassette must be installed and the pump latch closed. An alarm occurs if the cassette is removed during an infusion. The opto-module is located between the chassis and air-in-line sensor module. Cassette placement and pump latch position are sensed by the optomodule which includes four infrared LED-phototransistor pairs. Cassette placement is sensed by three transmissive pairs (see Figures 2-16 and 2-16a). When the cassette is installed, the cassette I.D. optics modify the path of the light beam. Cassette I.D. optics can either be light pipes or a prism that deflects the light beam. This provides a 3-bit code that can be read by the microprocessor. Future applications may use these codes to detect different cassette types. The pump latch position is sensed by the fourth LED photo-transistor pair, operating in a reflective mode. The slide link, which engages the pump latch and the cassette slide clamp, has a hot-stamped foil reflector. When the latch is closed, the reflector is located over the sensor, resulting in a logical high output.

The cassette and latch sensing circuit are controlled by software to minimize power consumption. Five output ports enable the LED-phototransistor pairs. Two of the output ports are control lines for turning on the LEDs. Three control lines are used to select which phototransistor output is connected to the A/D converter. Software then compares the sampled values with calibration constants stored in memory to determine cassette and latch states. Calibration compensates for variations in the current transfer ratio of the LED and phototransistor pairs.

B. Air-in-line Detection

Ultrasonic transduction methods are used to detect air in the tubing as it exits the cassette. The tubing is placed between an ultrasonic transmitter and a receiver crystal, which are mounted inside the tubing recess of the air-in-line sensor module. Fluids readily propagate high-frequency ultrasonic energy, while air is a very poor conductor. The output of the receiver is converted to a digital signal for software interpretation of the air bubble volume.

A block diagram of the air-in-line detection system is shown in Figures 2-17 and 2-17a. A voltage-controlled oscillator (VCO) provides the excitation for the transmitter piezoelectric crystal. The VCO sweeps through a range of frequencies to ensure that the resonant peak of the crystal is excited. Strobe logic operates the VCO intermittently to reduce power consumption. The output of the receiver is converted to a digital pulse by a comparator when a sufficiently large signal is detected. Fluid in the tubing results in a series of comparator output pulses due to the intermittent operation of the VCO. Air in the tubing results in no output pulses. The comparator output pulses trigger a one-shot which converts the pulsed or non-pulsed input into a high (fluid) or low (air) level output which is then latched in a PLD on the MEA.

The volume of air and fluid present at the detector is determined by the microprocessor. The sensor output latch for each channel is connected to an input port. An interrupt is generated by the edge of an air bubble. The software responds to the interrupt by reading the sensor input ports for all three channels (A,B, and C). An algorithm determines which channel caused the interrupt and whether fluid or air

is present. The interrupt latch is then cleared. The volume of fluid or air is determined by accumulated encoder counts. Software also polls the sensor input ports every motor revolution to check for conditions in which air is present from the beginning. Such a condition would result in no interrupt. An alarm occurs if the total amount of air exceeds a threshold value.

Additional information on air-in-line alarm algorithms and threshold methods is included in the Operating Instructions. Self-test is performed during the fill stroke by switching to a nonresonant frequency which simulates the presence of air.

Figure 2-16. Block Diagram of Cassette I.D. and Latch Sensors (Model2860)

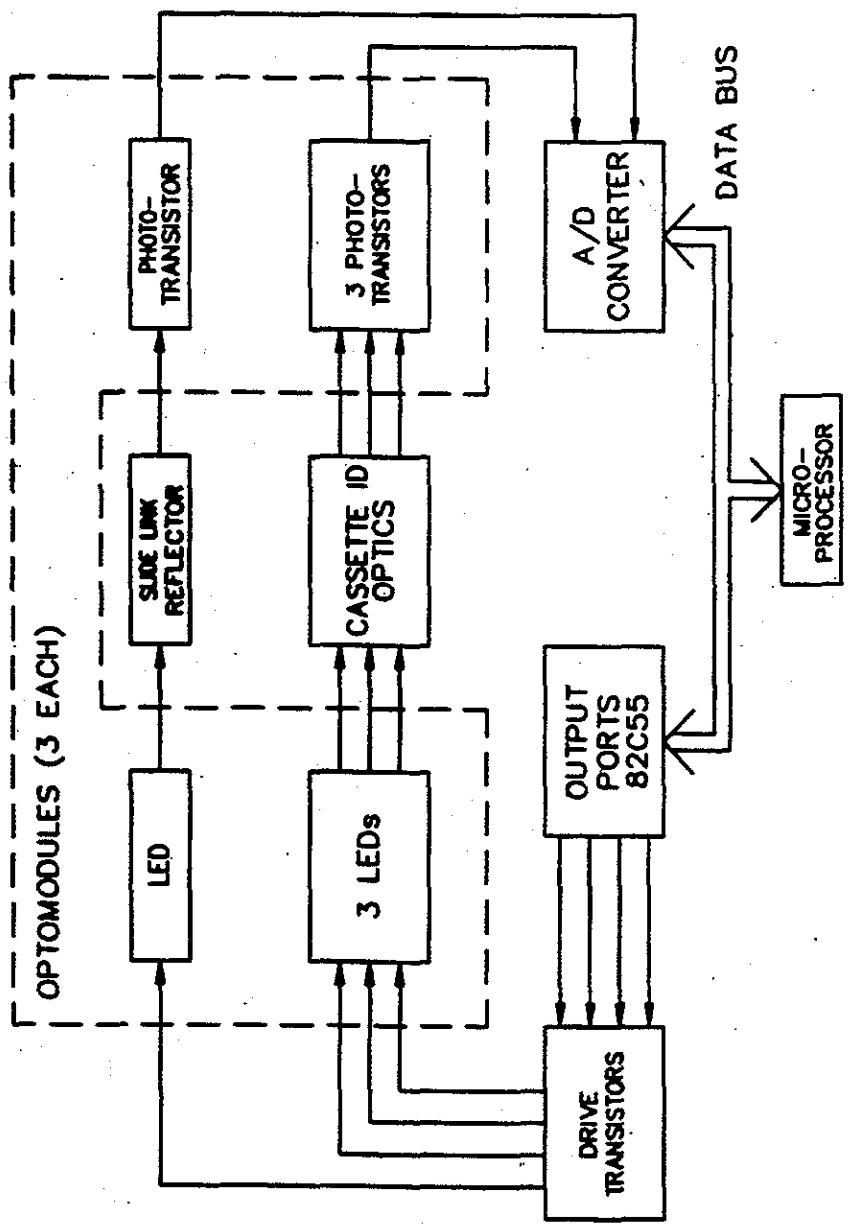


Figure 2-16a. Block Diagram of Cassette I.D. and Latch Sensors (Model2863)

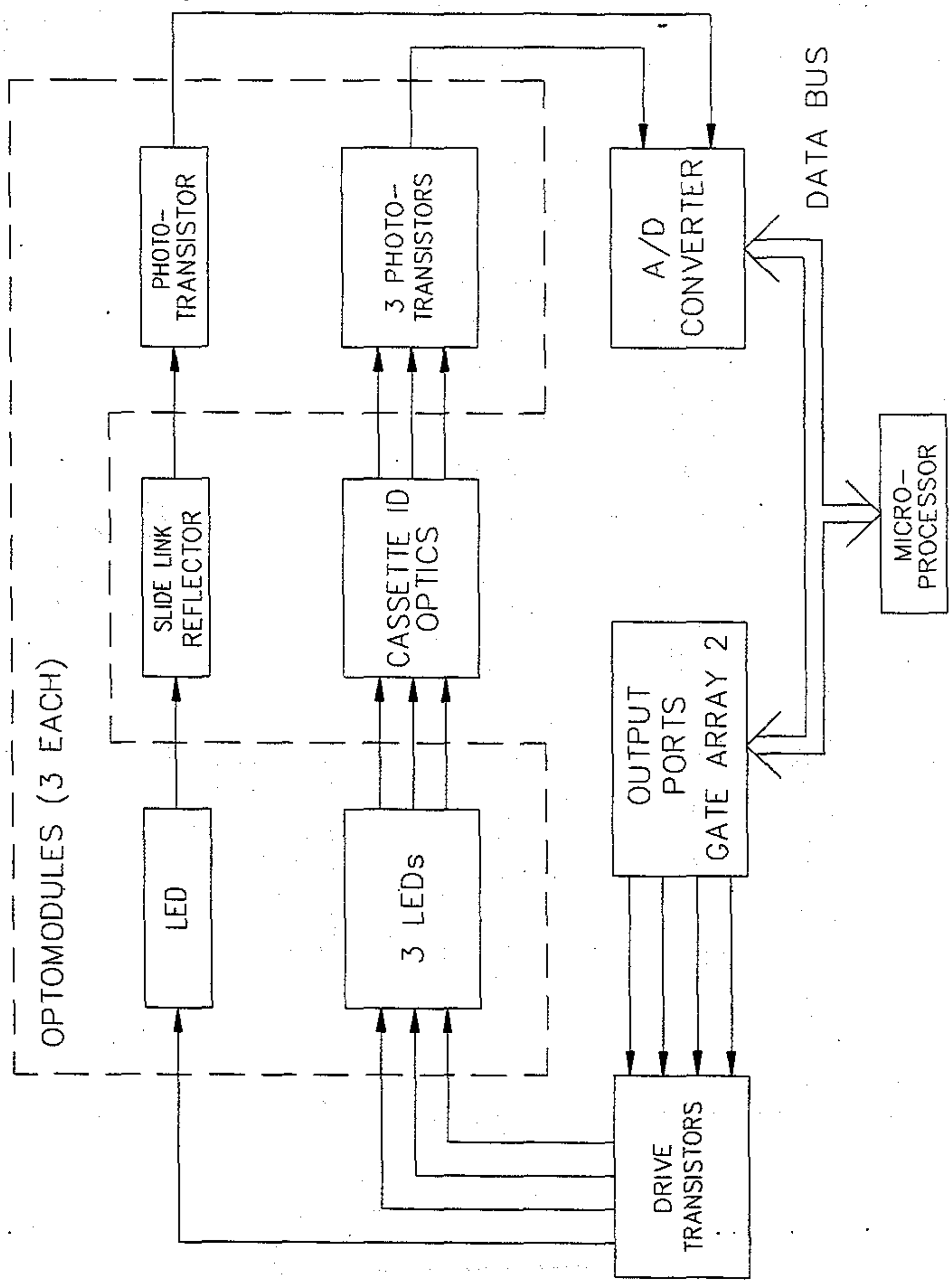


Figure 2-17. Block Diagram of Air-in-line Sensor System (Model 2860)

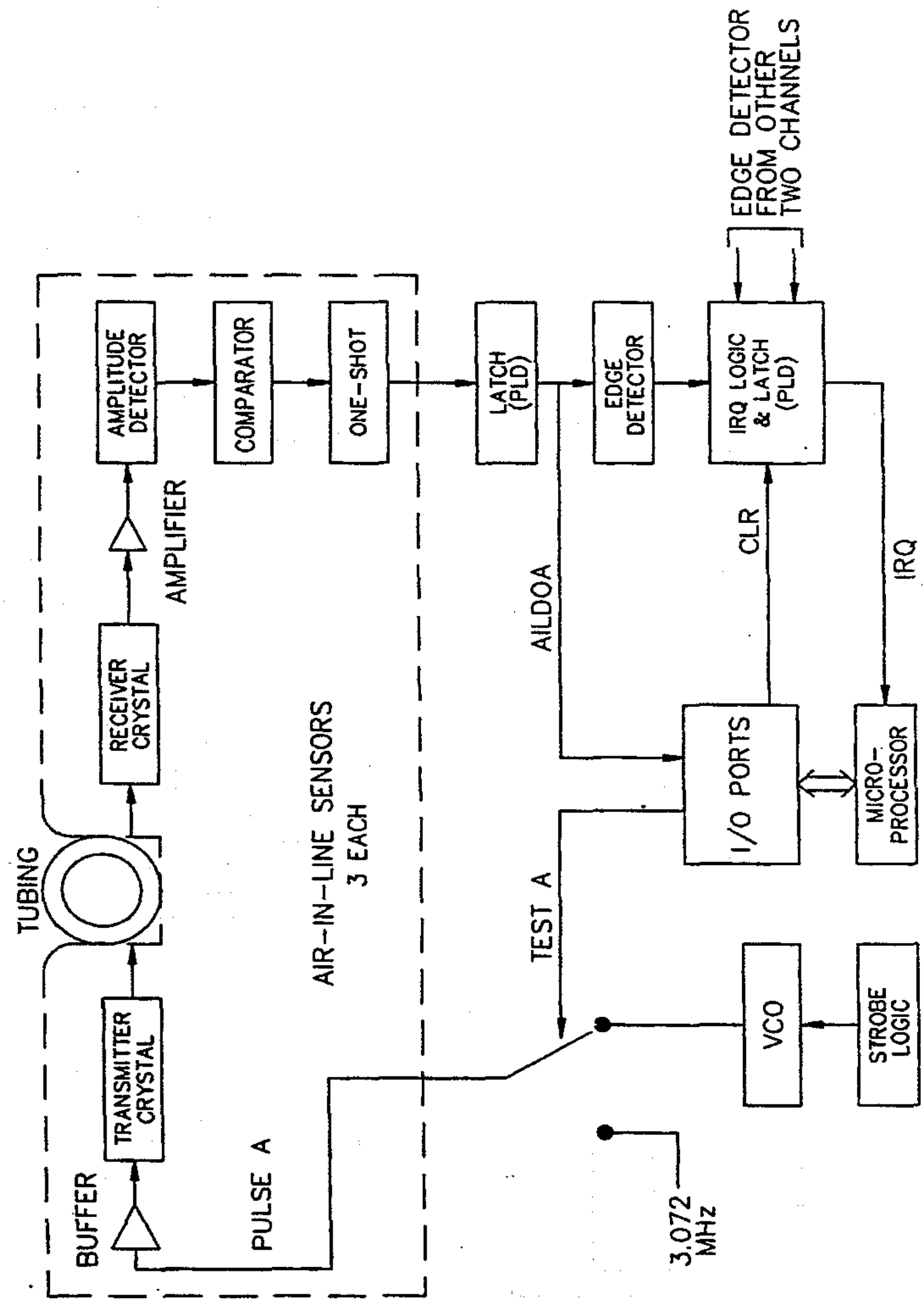
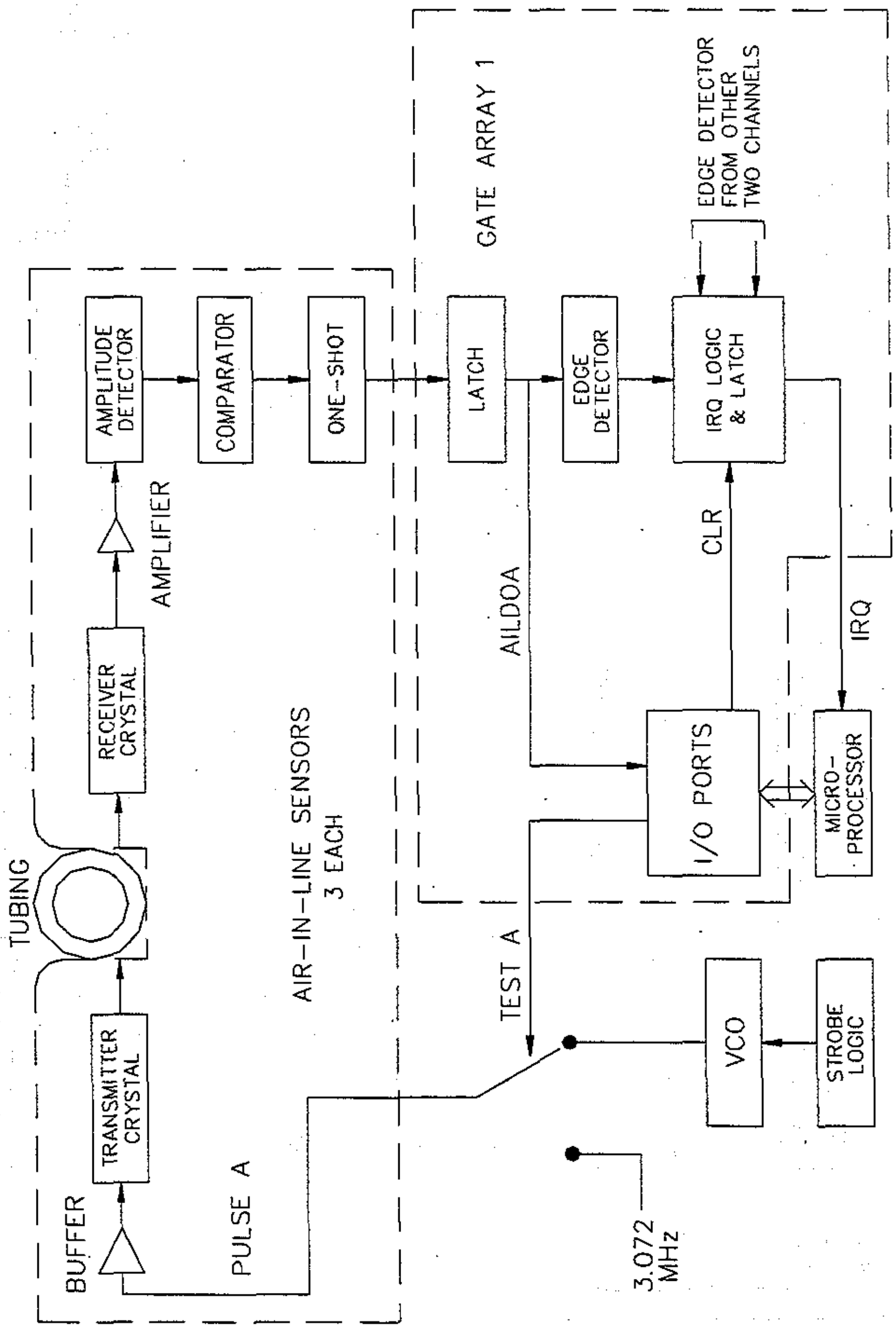


Figure 2-17a. Block Diagram of Air-in-line Sensor System (Model 2863)



C. Patient-side Occlusion Detection

Occlusions between the pump and the patient are detected from measurements of pressure in the line. A semiconductor strain gauge pressure transducer is mounted in the chassis. The elastomeric pressure sensing dome in the cassette (see Figure 2-2) transmits pressure to the transducer. The power to the strain gauge is strobed to reduce power consumption.

The transducer output is amplified and low-pass filtered (see Figure 2-18). This switched capacitor filter attenuates motion artifacts and smoothes arterial pressure waveforms. The filtered signal is sampled by the A/D converter. The microprocessor uses calibration constants to convert A/D counts to the correct pressure units. Zeroing is performed each time the cassette is removed. Alarm thresholds are determined using either a baselining or absolute method, depending on the Device Type setting (refer to the Directions For Use).

Self-tests are performed to determine if there is a fault condition in the transducer. The strain gauge is tested by measuring the common mode output voltage from one leg of the bridge. Limits are also placed on the maximum allowable zero offset.

D. Fluid-side Occlusion Detection

Occlusions between the container and the pump may occur due to a closed regulating clamp, a closed vent (with an unvented container), kinked tubing, an empty syringe, or any restriction to flow. The fluid-side occlusion detection system detects these conditions, as well as empty syringes. The system is based on integrating the motor current during the fill portion of the pumping cycle (see Figure 2-19). During an occlusion on the container side, the motor draws more current and slows down. Current is sensed by a 1-ohm shunt resistor in the motor return line. The current is integrated using an operational amplifier with a feedback capacitor. Integrator mode (i.e., reset, integrate, or hold) is controlled by encoder markers that operate transmission gate switches. The leading edge of the home marker resets the feedback capacitor. At the trailing edge of the home marker, the transmission gate switches are configured to perform integration. At the rising edge of the DEL marker, the integration is stopped. This places the output in hold. When software detects the delivery stroke, by polling the DEL input port, the A/D converter reads the integrator output. If the sampled value exceeds the alarm threshold that is computed using calibration data and an occlusion detection algorithm, an alarm occurs. Note that measurements are always made with the motors operating at 5V. When infusing at high rates (i.e., greater than 275 ml/h), which uses the 13V drive, every fifth motor pulse uses 5V for one revolution.

2.7 Power Supply

Power is supplied to the instrument by a system that consists of an AC adapter, rechargeable nickel cadmium (NiCd) battery pack, and a regulating power supply module. The power supply module is comprised of seven basic elements: four power converters, a battery charger, an on/off circuit, and a power control switch (see Figure 2-20).

A. Alternating Current Adapter

The AC adapter converts line voltage into unregulated 9V DC power (unloaded),

referred to as Vext. The AC adapter is external to the instrument and connects to the power module board via the audio/connector PCBA. The internal transformer isolates the instrument. This results in leakage current of less than 100 microamperes. The output of the transformer is full-wave rectified by a diode bridge, and low-pass filtered by electrolytic capacitors. A nonresettable thermal fuse is incorporated in the primary winding of the transformer to protect against fault conditions. The AC adapter also provides earth grounding.

Figure 2-18. Block Diagram of Patient-side Occlusion Detection System Circuit

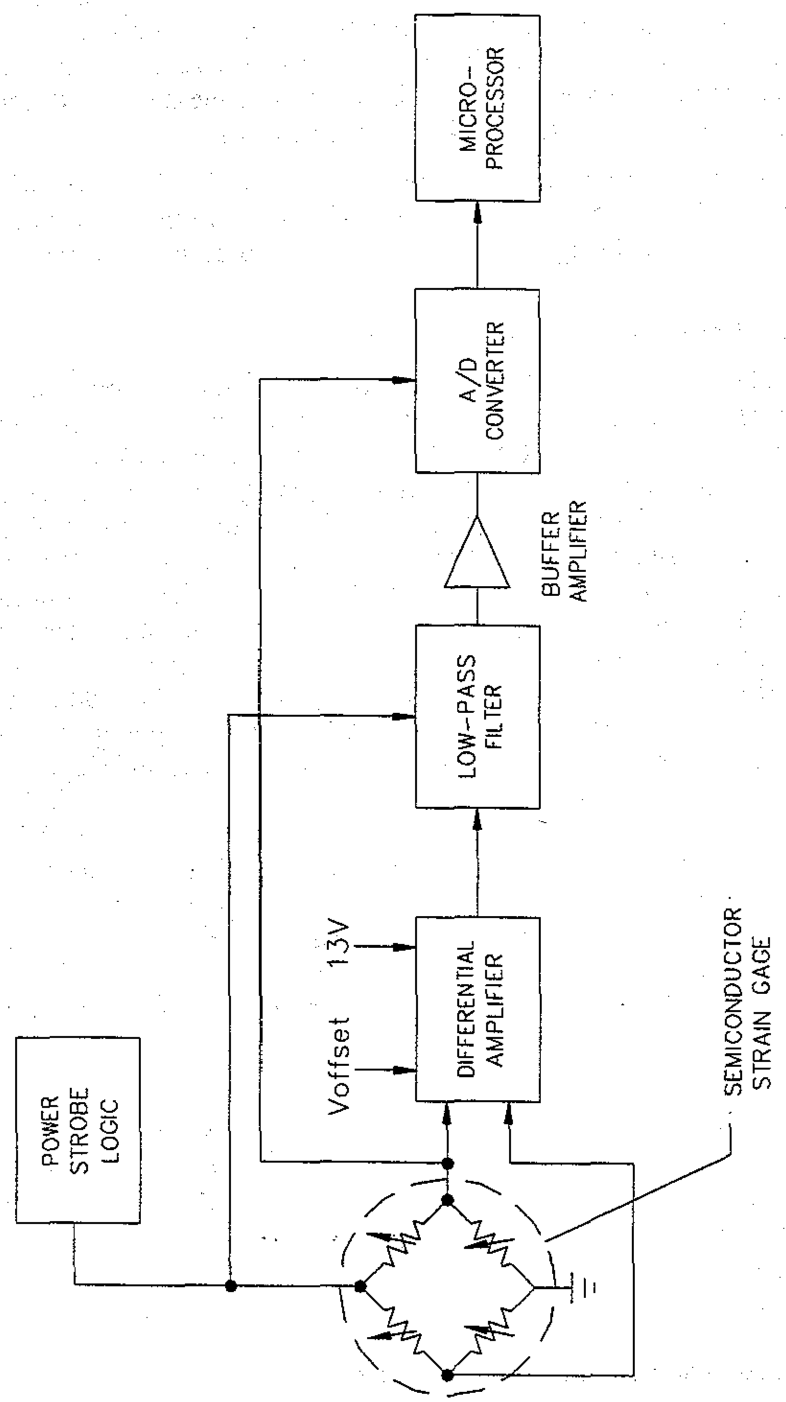


Figure 2-19. Block Diagram of Fluid-side Occlusion Detection System Circuit

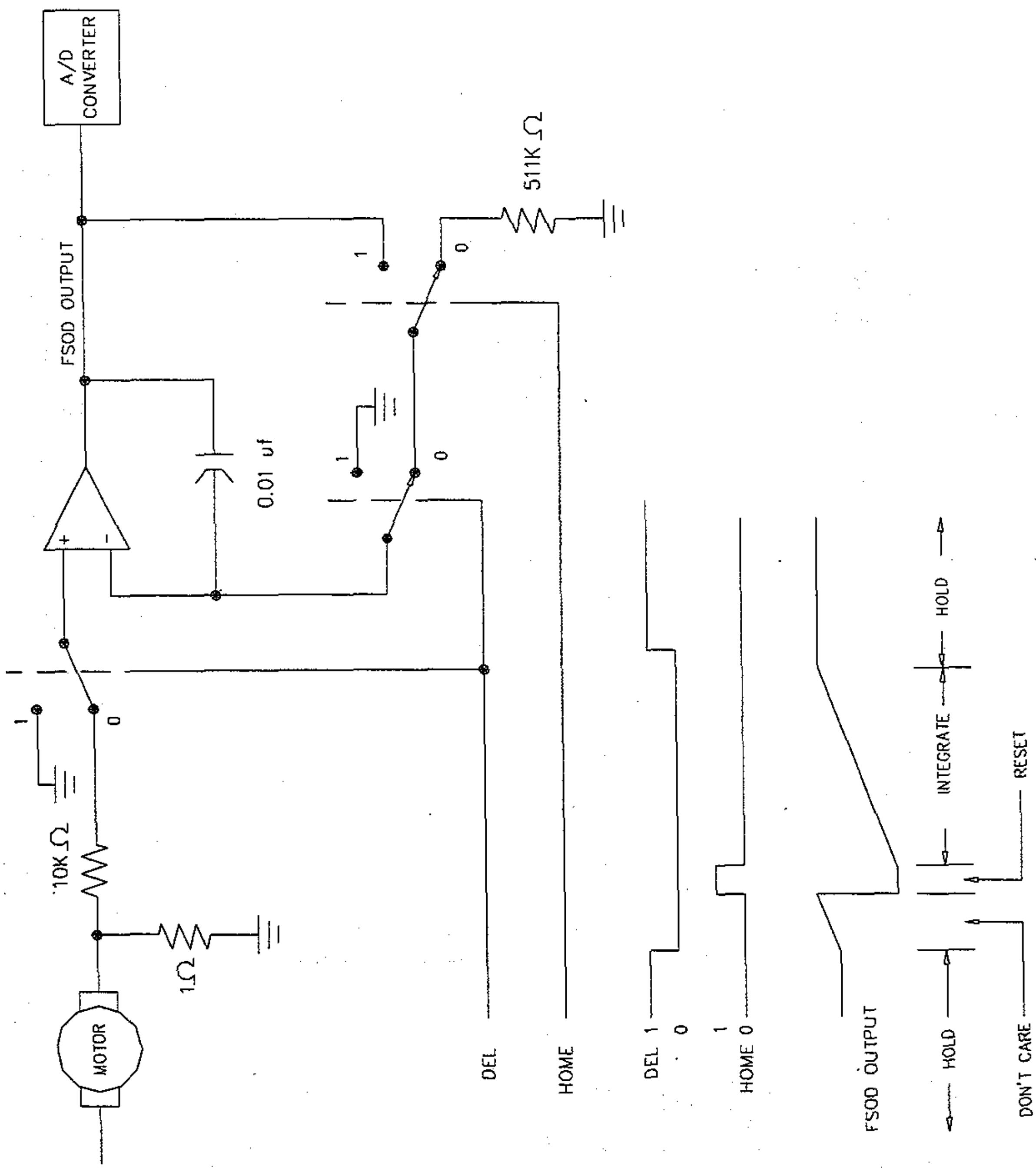
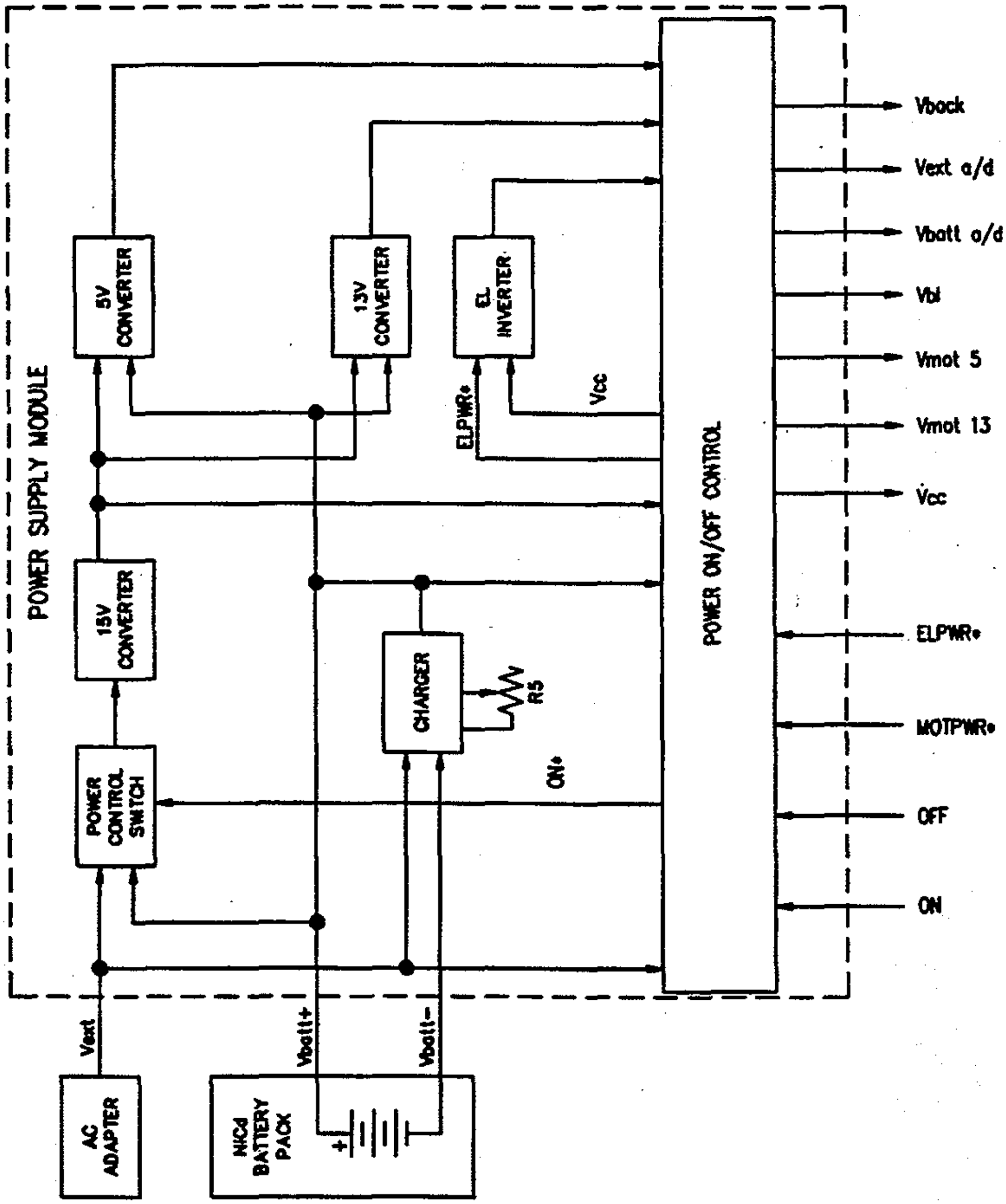


Figure 2-20. Block Diagram of Power Supply Module



B. Nickel Cadmium Batteries

Without Vext, the instrument is powered by three 1700-mAh rechargeable NiCd cells connected in series. The three cells are contained in the battery pack attached to the top of the main housing. Nominal voltage is 1.2V per cell. A self-resetting thermal fuse is included in the battery pack to protect against fault conditions. The batteries connect directly to the power PCBA. The inside of the battery pack housing is coated with a thin layer of aluminum to provide shielding against electromagnetic interference and electrostatic discharges.

> ***WARNING***
>
> *Failure to use MedSystem replacement batteries can cause false low-battery alarms.*

C. Power Converters

The four power converters generate +5V and +13V for the MedSystem III electronics and motors, AC power to drive the electroluminescent (EL) backlight panel behind the front panel LCD, and +15V for use in the power supply module. The 5V and 13V circuits convert unregulated battery voltage into regulated voltage of 5V and 13V DC. This is accomplished by using two step-up switching regulators (MAX643) with over-voltage protection. The 15V circuit converts unregulated AC adapter and battery voltage to regulated 15V DC power. This then supplies the high-voltage gate drive to MOSFET switches elsewhere in the power supply. The 15V converter is a boost regulator that uses a MAX643 step-up switching regulator configured for bootstrapped operation. The EL power converter transforms +5V DC power from the power on/off circuit to 80 Vrms, 400-Hz AC power, using a tank circuit and a step-up transformer.

Backlighting power is controlled by the output port ELPWR*. The EL inverter output is applied directly to the EL backlighting panel located behind the LCD.

D. Power Control Switch

The power source to the 15V converter is determined by the control switching circuit. When the AC adapter is plugged into the instrument, Vext is applied to the 15V converter by the external power control circuit. A metal-oxide varistor (MOV) protects input circuitry from high-voltage transients. Without Vext, Vbatt is gated to the 15V converter.

E. Charger Circuit

Whenever the AC adapter is used, the charging circuit restores the NiCd battery charge, and simultaneously powers the instrument. A step-up/step-down regulator converts power from Vext to the battery. It also supplies current to the battery and the 5V and 13V converters. Charge current is regulated by a feedback circuit that senses current in the negative battery terminal. The charge rate is set to an average current of 170 milliamps by potentiometer R5.

F. Power On/Off Control Circuit

The power on/off circuit controls the power supply module outputs. When the ON signal is strobed by the keypad, the power on/off circuit asserts ON*, powering up the 15V converter. The presence of 15V activates the +5V and +13V converters.

Five volts is immediately provided to the MEA, powering up the microprocessor system. Signals MOTPWR* and ELPWR* from an output port determine when the +13V and 80 Vrms supplies are asserted as outputs from the power supply module.

When the OFF signal is strobed by the microprocessor, ON* goes high, disconnecting all power module outputs; thereby, powering down the MEA. Power supply circuits are isolated from the MEA by MOSFET switches.

G. Monitoring the Power Supply

Two signals from the power supply module are monitored by the microprocessor via the A/D converter. The Vext A/D signal is used to determine whether the AC adapter is powering the instrument. The Vbatt A/D signal provides battery charge information. These two signals are used to initiate or suppress low-battery advisories and alarms.

Chapter 3
System Functional Tests

3.0 System Functional Tests

Functional tests are recommended prior to clinical use, after repair or calibration, and annually as part of annual preventive maintenance. When a test requires a primed cassette, it is recommended that saline solution be used for such tests. If any of the functions are not as described in the check procedures, then the instrument requires service. Refer to Chapters 1 and 2 for diagrams which illustrate component names and placement of parts. Refer to Chapter 6 for information on troubleshooting specific problems. See Section 6.4 for a cross-reference listing of event codes and problems.

WARNING

For proper grounding, the AC adapter must always be connected to a three-wire outlet. Never operate the MedSystem III System from a two-wire, ungrounded outlet.

WARNING

Do not perform any of the following tests while the system is in use on a patient. Review all precautions in the Directions for Use before performing these tests.

NOTE: *Upon completion of system functional tests, reset the following: Volume Remaining, Time, and Rate.*

3.1 Electrical Safety Test

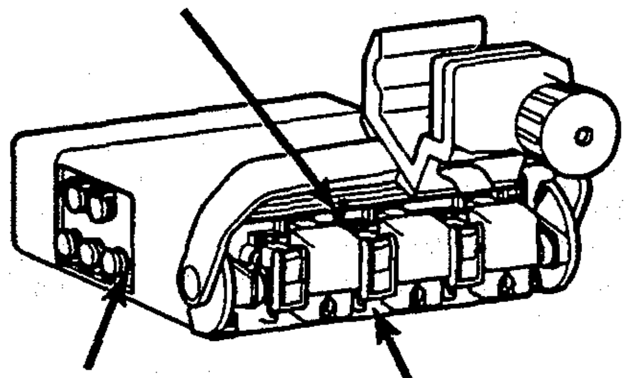
Tests for leakage current and for ground continuity are recommended in accordance with the requirements listed under NFPA99, UL 544, and ANSI/ AAMI ES1, 7/85. The suggested grounding point on the instrument for these tests is the chassis (see Figure 3-1).

NOTE: *Electrical safety test can only be performed with AC adapter connected to the unit.*

NOTE: *The pole clamp is isolated from the internal electronics and, therefore, is not grounded. It should not be used while performing electrical safety tests.*

NOTE: *The chassis of some instruments is coated with a black protective material that is nonconductive. If your instrument has this coating, use the uncoated test point located toward the back of the chassis under the lower housing (see Figure 3-1).*

Figure 3-1. Test Point for Instrument with Black-coated Chassis



3.2 Power Tests

A. Power-up Test

Charge the instrument for at least one hour before performing this test.

Proceed with the power-up test as follows:

1. Disconnect the AC adapter from the instrument.
2. Remove any cassettes installed in the instrument.
3. Turn the instrument on and verify proper power-up, as described in the MedSystem III™ Directions for Use.
4. The instrument performs initial self-test during power-up; and, if it detects any problems, it will indicate a fault.
5. Check audio and keypad operation by ensuring there is a soft beep for each key press.
6. Press any key and ensure the LCD backlight turns on.

NOTE: *For a complete memory self-test, the instrument should be turned on for a minimum of 10 minutes for the Model 2860 and 18 minutes for the Model 2863 instruments. It is not necessary for the unit to be pumping to perform this test. If operating on battery power, a cassette must be installed in at least one of the channels and that channel put in standby mode; otherwise, the instrument will automatically shut off after five minutes of inactivity.*

B. AC Power Test

1. Turn on the instrument without the AC adapter attached.
2. Install a primed cassette in each pump channel.
3. Start all channels (at any rate). Verify the green LED on each channel blinks during operation.

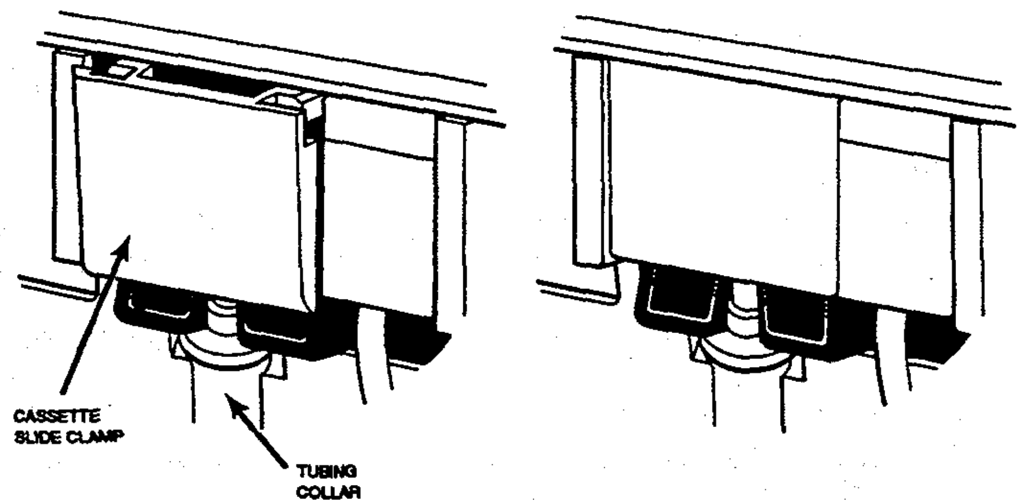
4. Attach the AC adapter to the pump. Verify that the instrument beeps three times when the connector is properly installed. Verify that the green plug-shaped light on the side connector panel is lit and does not blink if you wiggle the connector.
5. Verify that the green LEDs for each channel key (A, B, and C) are steadily illuminated. If they are blinking, then the instrument is not recognizing that AC power is connected.

3.3 Cassette and Sensor Test

This test verifies the proper functioning of the cassette and latch sensors, as well as the latching mechanisms. Repeat the following procedures for all three channels (A, B, and C).

1. With the instrument off, remove any cassettes that are installed in the instrument.
2. Turn on the instrument.
3. Verify that the pump latch mechanism of each channel returns to the Home position at the top of the stroke (nearest to the chassis).
4. Press the channel select key (A, B, or C), and then press the START/STOP key. A two-tone advisory will sound, and the highlighted message *Install Cassette* will appear in the prompt line near the bottom of the screen.
5. Install a primed cassette into the appropriate channel (A, B, or C), but do not push the cassette slide clamp into place (see Figure 3-2A). Ensure that there are no air bubbles.
6. Again press the START/STOP key. A two-tone sound will be emitted, and the message *Push slide clamp in* will appear at the bottom of the page.
7. Push the cassette slide clamp in (see Figure 3-2B), and seat the tubing collar in the recess below the cassette. Three beeps will sound to indicate correct cassette installation and fluid in the sensor pathway. The cassette should latch easily and smoothly. If the air-in-line sensor detects air when a cassette is installed, a *Check Air Sensor* advisory will be displayed.
8. Press the START/STOP key. The message *Infusing* will appear on the channel status line.
9. While the channel is pumping, pull out the cassette slide clamp. You will hear a repeating four-beep audio alarm and the red LEDs will blink. Infusion will stop and the display will indicate a *Cassette Not Latched* alarm.
10. Remove the cassette. The alarm display should read *Cassette Removed.* Reset the alarm by pressing the channel select key (A, B, or C) for the channel in use, and press the CANCEL softkey.

Figure 3-2. Cassette Installation



A. SLIDE CLAMP NOT IN PLACE

B. SLIDE CLAMP IN PLACE

3.4 Patient-side Occlusion Detector Test

This test verifies the proper functioning of the alarm which detects occlusion between the instrument and the patient. Repeat the following steps for each of the three channels, A, B, and C.

1. Connect a set to a fluid container and prime. Ensure there are no air bubbles.
2. Ensure the instrument is turned on.
3. Install the primed set.
4. Press the appropriate channel key (A, B, or C) to select the programming page for the channel to be tested.
5. Set the infusion rate for the selected test channel to 125 ml/h, and set the volume remaining to 100 milliliters.
6. Ensure that the roller clamp is open and caps are removed. Press the START/STOP key and verify that fluid is flowing.
7. Fold and pinch the patient-side tubing just below the instrument.

   When the patient-side occlusion is detected, the Standard Display will show an alarm for the test channel and will also show the message *Patient Side Occluded.* The red LED in the key for the test channel will blink, and an audible four-beep alarm will sound.
8. Release the tubing and press the START/STOP key to reset the alarm.

NOTE: *A more accurate patient-side occlusion test can be performed by configuring the instrument in the Controller Pressure Device Type, which has an absolute nominal occlusion pressure of three feet of water (see Directions for Use). Use a set which contains no filters or check valves, and which has macro bore tubing on the patient side. Set the infusion rate for 1 ml/h, and raise the patient-side tubing outlet two feet, two inches above the cassette. The channel should not sound an alarm. Next, slowly raise the tubing outlet three feet, eight inches above the cassette. The channel should sound an alarm within 10 seconds.*

3.5 Fluid-side Occlusion Detector Test

This test verifies the proper functioning of the alarm that detects occlusions between the instrument and the fluid container. Repeat the following procedure for each of the three channels, A, B, and C.

1. Install a primed set in the selected channel.
2. Start the selected channel at 125 ml/h.
3. Close the roller clamp between the instrument and the fluid container. The occlusion should be detected within two minutes.
4. The Standard Display screen will show an alarm for the channel under test and also the message *Fluid Side Occluded.* The red LED in the key for the test channel will blink, and an audible four-beep alarm will sound.
5. Open the roller clamp and press the START/STOP key to reset the alarm.

3.6 Air-in-line Detector Test

This test verifies the proper functioning of the alarm which detects air in a line.

Repeat the following procedure for each of the channels, A, B, and C.

1. Disconnect the drip chamber from the solution bottle, or inject a large air bubble into the tubing via the upstream y-site.

   NOTE: *The injected air bubble size should be approximately twice the threshold value of the air detector plus one milliliter to fill the cassette air trap. For example, if the threshold is 500 microliters, then inject a 2-milliliter air bubble. To determine the threshold value, check the Clinical Configuration settings in the instrument (see Directions for Use).*
2. Press the START/STOP key on the selected cassette. When the bubble is pumped through the cassette, the Standard Display should show an alarm for the channel under test with the message, *Air In Line.* An audible four-beep alarm will sound and the red LEDs will blink.

3.7 Volume Accuracy Test

Accuracy of fluid delivery is determined by measuring the volume of fluid delivered over a known time period and comparing this measurement to the expected value. To ensure accurate measurements during this test, a volumetric glass burette (class A) must be used to collect the fluid. The infusion time interval, which is measured manually with a stopwatch with a precision of 0.1 second, must be 180 seconds or greater to minimize measurement errors. During a 180-second test, a one-second error by the operator results in an error of 0.6%.

The expected volume is calculated from the programmed rate and the measured time interval. The volume collected should be large enough to minimize errors in reading the burette. See Table 3-1 for the test parameters recommended by the AAMI proposed infusion device standard.

WARNING

Proper operation of the valve actuator return springs is essential for accurate fluid delivery when using negative input pressures. Negative input pressures occur as a result of negative head heights, viscous solutions, or syringe use.

Checking the spring function is accomplished by testing volume accuracy, using conditions of negative head height (at least -2.5 feet) and a rate greater than 275 ml/h. These conditions are recommended for annual functional tests, or if the valving mechanism was disassembled.

Table 3-1. Volume Accuracy Test Parameters

Rate (ml/h)	Minimum Collection Volume (ml)	Nominal Collection Time (min.)	Burette Size (min.)
5	10	120	10
10	10	60	10
50	25	30	25
100	25	15	25
250	50	12	50
500	50	6	50
999	50	3	50

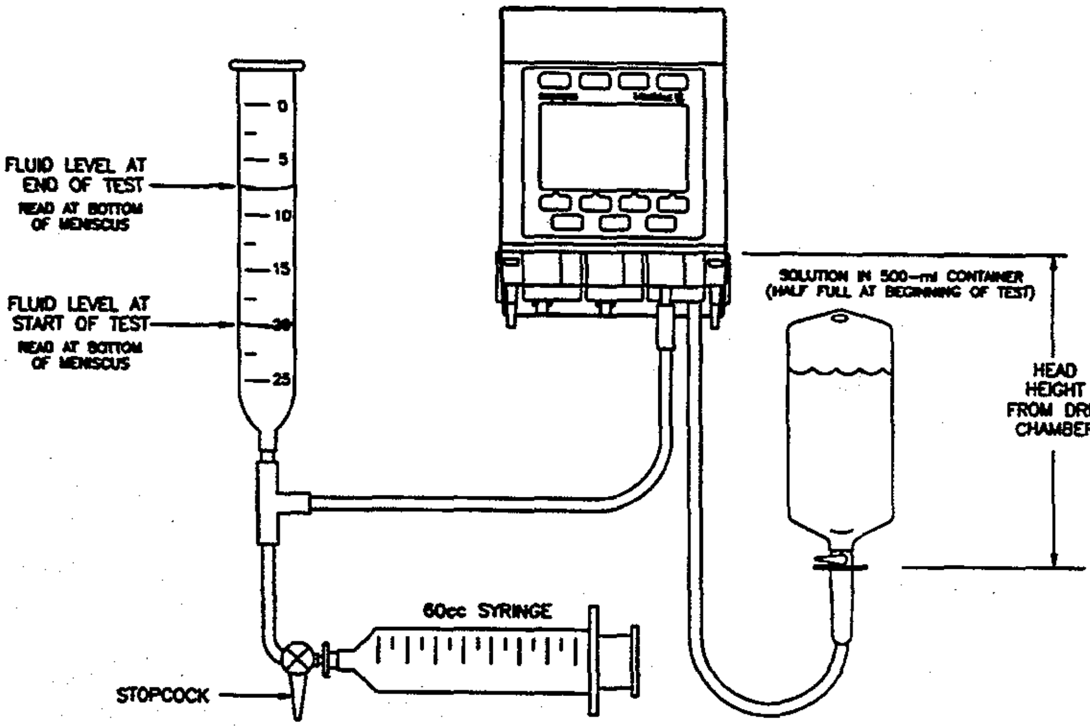
NOTES:

1. Interpolation shall be to the next lower specified flow rate's collection volume, and collection time shall be the collection volume divided by the flow rate.
2. If the flow rate to be tested falls between two specified rates, choose the collection volume for the next lower rate. For example, to test at 150 ml/h, choose a collection volume of 25 ml in a burette of 25 ml, with the resulting collection time being 10 minutes.

A. Test Equipment Setup

1. Obtain a new set and connect it to a 500-milliliter container which is at least half full. Prime the set and eliminate all air.
2. Connect the apparatus as shown in Figure 3-3. Use a volumetric burette marked in 0.1-milliliter increments (class A glassware).
3. Install the cassette into the channel being tested. If testing valve actuator springs, adjust the fluid level in the container to at least 2.5 feet below the cassette.

Figure 3-3. Test Equipment Setup



B. Calculations

Vm = Volume measured (ml) = (Initial fluid level - Final fluid level)
R = Rate (ml/h)
T = Time interval measured (seconds)
Ve = volume expected (ml)

Ve = R•T/3600
% Error = 100•(Vm - Ve)/Ve

C. Procedure

1. Set the rate to the desired value for the channel being tested. Set the volume remaining greater than the expected volume (e.g., 100 ml) to ensure the infusion does not switch to a keep vein open (KVO) rate during testing.
2. Open the stopcock to the syringe and adjust the bottom of the meniscus to a convenient level. Record this level. Close the stopcock.
3. Simultaneously start the infusion and stopwatch.
4. When the infusion time is near nominal collection time, simultaneously stop the infusion and stopwatch.
5. Read the fluid level at the bottom of the meniscus and record this value. Read the stopwatch time and record the value.
6. Calculate the volume delivered, the volume expected, and the percent of error. For Device specifications, see Appendix A.

Example:

Rate = 500 ml/h
Initial fluid level = 50.0 ml
Measured time = 350 sec.
Final fluid level = 0.9 ml

Ve = R•T/3600 = 500•350/3600 = 48.61 ml
Vm= 50.0 - 0.9 = 49.1 ml

% Error = 100•(Vm - Ve)/Ve
= 100•(49.1 - 48.61)/48.61
= 1.0%

3.8 Battery Operating Time

Perform the following procedures to test battery life.

1. Ensure that the instrument has been charged for 14 continuous hours prior to performing this procedure.
2. Turn the instrument on with an AC adapter connected. Disconnect the AC adapter. Run the instrument at 125 ml/h concurrently on all three channels: A, B, and C (a total of 375 ml/h).

   NOTE: *Key presses and alarms during the test period can result in reduced battery operating time. Therefore, minimize these events during this test.*
3. Assure that a Low Battery advisory does not occur for at least 5.5 hours of operating time.
4. Assure that a Battery Depleted alarm does not occur for at least 30 minutes after the onset of the Low Battery advisory.
5. Assure that the Battery Depleted alarm continues for at least five minutes before the instrument shuts off.
6. Recharge the instrument for 14 hours.

The Battery History Log automatically records the time intervals required by the above test.

3.9 Watchdog Audio Test

Manually test the Watchdog Alarm Audio from the Standard Display. Press the More Options button several times until a softkey labeled Demo WD appears. Press this key and follow the directions on the screen for completing the Watchdog Test.

TABLE OF CONTENTS

LIST OF FIGURES

Chapter 4
Maintenance

4.0 Maintenance

The MedSystem III Infusion System is designed for reliable, long-term operation. However, annual preventive maintenance is required to maintain optimum performance and to detect the need for repair or adjustment. Preventive maintenance regimes are typically established by your institutional policies. These policies should consider local experiences and usage patterns.

4.1 Cleaning Procedure

> *WARNING*
>
> *Before cleaning, unplug the AC adapter from the AC wall outlet and from the instrument.*

> *CAUTION*
>
> *DO NOT STEAM STERILIZE, ETO STERILIZE, OR AUTOCLAVE THE INSTRUMENT. DO NOT IMMERSE the instrument. DO NOT allow fluids to enter the instrument. Ensure that the instrument is kept in an* ***upright position*** *when cleaning to prevent fluids from possibly leaking into the instrument. The MedSystem III is designed to be splash-proof only. Inspection should be performed before cleaning to ensure that there is no damage that could cause fluid to enter the case interior.*

> *WARNING*
>
> *Never apply alcohol to a cassette intended for patient use.*

The steps which follow should be used to keep the instrument clean.

A. Cleaning Solutions

> *CAUTION*
>
> *DO NOT use organic solvents, ammonia, or ammonium-based agents for cleaning. Isopropyl alcohol may be used for wiping specified external surfaces only, as directed in the MedSystem III manuals. Prolonged or repeated exposure to isopropyl alcohol can damage plastic parts. Refer to warning in Appendix H-1.*

Refer to the Environmental Services, Central Service, or Infection Control Departments in your facility for further information on appropriate cleaning agents.

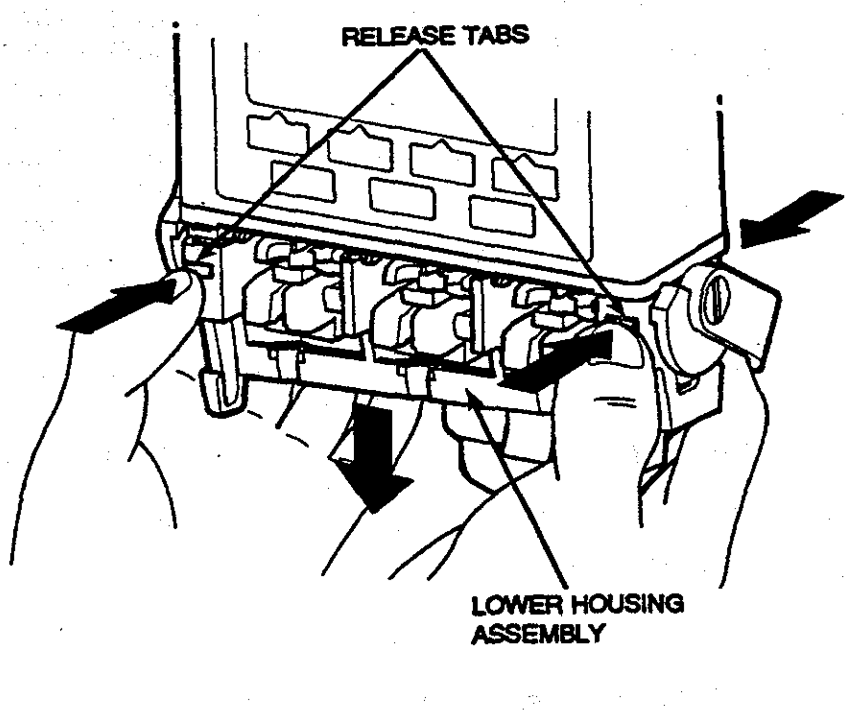
B. Instrument Exterior

Routinely clean the exterior surfaces of the instrument. Use a cloth dampened with warm water and a mild, nonabrasive, nonstaining standard hospital disinfectant or a detergent (i.e., commercially available dishwashing liquid). Dilute the disinfectant or detergent with water. Isopropyl alcohol may be used to wipe the housing exterior.

C. Lower Housing and Pumping Mechanism

To access these components, first remove the lower plastic housing by depressing the four black release tabs in the upper corners. Next, pull straight down (see Figure 4-1). A small soft-bristled brush helps in cleaning the pump latch mechanism and linkages. If the slide link or pump latch mechanisms stick, spray with an acceptable cleaning solution (see Figure 4-2). To loosen severely contaminated mechanisms, let cleaning solutions permeate for an extended time. Thoroughly dry the mechanisms after cleaning, using clean pressurized air.

Figure 4-1. Lower Housing Removal for Pumping Mechanism Access



D. Air-in-line Sensor

The air-in-line sensor tubing recess must be free of debris, dirt, or dried solutions. Wipe the tubing recess (see Figure 4-3) with a nonabrasive cloth, pad, or swab moistened with isopropyl alcohol. Remove excess alcohol with a dry, lint-free swab.

Figure 4-2. Contaminant Removal from Slide Link and Pump Latch Mechanisms

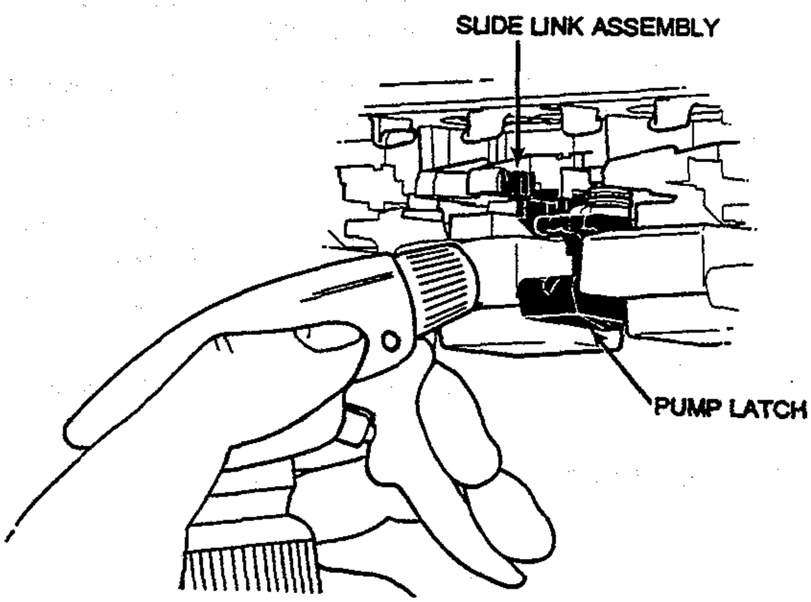
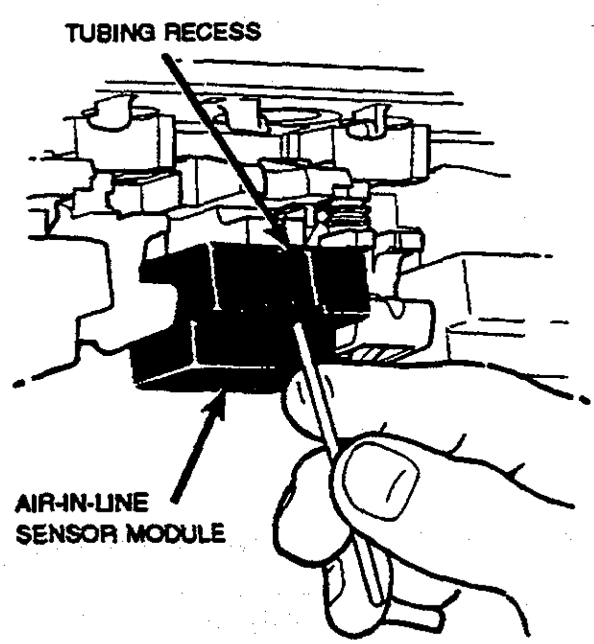


Figure 4-3. Contaminant Removal from Air-in-line Sensor Tubing Recess



E. Optomodule

WARNING

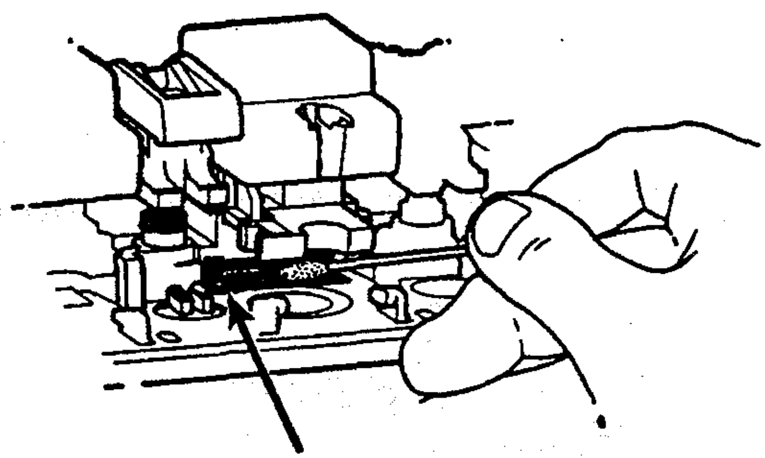
When cleaning the optomodule, use EXTREME CARE to avoid damage to valve actuators. If valve actuators are damaged, a free-flow condition could result.

Clean the optomodule with water or a very diluted mild detergent solution (see Figure 4-4). Wipe the surfaces dry with a lint-free swab.

CAUTION

DO NOT use isopropyl alcohol to clean the optomodule.

Figure 4-4. Contaminant Removal from Optomodule



F. Valve Actuators

CAUTION

Do not use organic solvents, ammonia, ammonium-based agents, isopropyl alcohol, and/or abrasive solutions for cleanings.

WARNING

Use EXTREME CARE when cleaning the valve actuators. Damage to the valve actuators can cause an uncontrolled flow condition. Do not clean with sharp or hard tools.

Clean the valve actuators with a non-abrasive, lint-free cloth and mild, non-abrasive, non-staining disinfectant or detergent. Dampen a swab with the cleaning solution. Gently remove any residue or contaminant from the valve actuators and the actuator seal, being extremely careful not to bend the valve actuators or tear the actuator seal. If dried residue is difficult to remove, perform the following steps (see Figure 4-5).

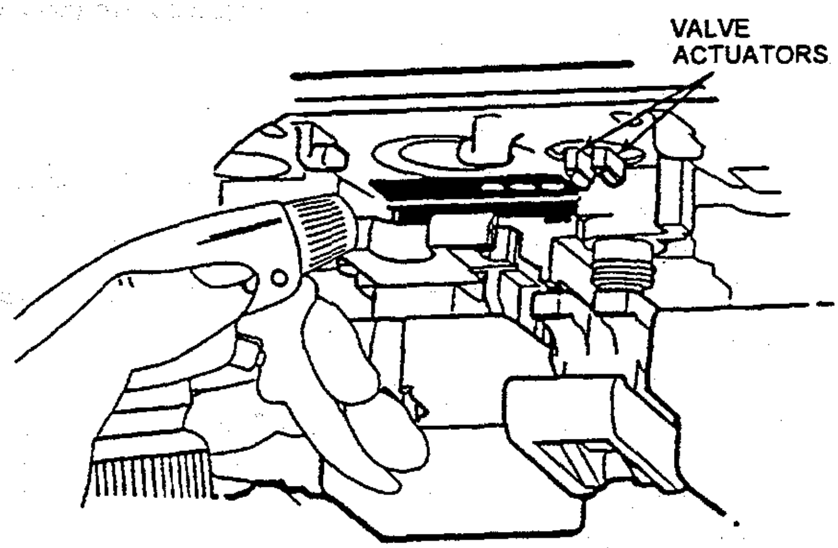
1. Set the pump upright and keep it upright while cleaning.

> ***CAUTION***
>
> *Ensure instrument is kept in an upright position when cleaning to prevent fluids from possibly leaking into the instrument.*

2. Spray the cleaning solution on the residue.
3. Keeping the pump upright, allow the residue to soften.
4. Gently wipe away the softened residue with a dampened swab.
5. If necessary, repeat steps 2 through 4 until the residue is removed.

Rinse the valve actuators with water and wipe with a dry swab.

Figure 4-5. Contaminant Removal from Valve Actuators



After cleaning, inspect the exposed tips of the valve actuators for damage by lightly pushing the tips of the valve actuators side to side with a dry swab. If the tip is not rigid, it is broken and must be replaced before using the pump.

NOTE: A broken valve actuator tip may be supported by the actuator seal and may not appear defective.

4.2 Annual Maintenance

It is recommended that annual maintenance be performed on the instrument. Such maintenance should be completed in the order presented in sections A through H which follow.

> **CAUTION**
>
> *Inspection should be performed before cleaning to ensure there is no damage that could cause fluid to enter the case interior.*

NOTE: *The instrument should be cleaned before calibration to remove dirt, dried solutions, and debris from the sensors.*

> **WARNING**
>
> *Functional tests should be performed at the completion of the annual maintenance check to ensure that the instrument performance is within the required specifications before being returned to patient use.*

A. Inspection

Certain defects can be determined by inspecting the instrument. Check for the following defects.

1. **AC Adapter**
   - AC power and ground prongs are not damaged or loose.
   - Housing is intact, free of cracks, and the side of the case is not bulged or dimpled.
   - Cable insulation is intact and not frayed or cut.
   - Instrument connector shell is intact and pins are not damaged.
2. **Pole Clamp**
   - Housing is not broken or cracked.
   - Instrument front-to-back indexing is firm.
   - Clamp rotates properly around the bracket.
   - Clutch operates and is adjusted properly.
   - Rubber pads are intact.
3. **Loose Parts**
   - Shake instrument to ensure that there are no loose internal parts.
4. **Main Housing**
   - There are no significant cosmetic defects.
   - Labels are intact.
   - Main housing is intact and free of cracks.
   - Audio/connector PCBA dust covers are intact and free of cracks.
   - Battery pack is flush with top of case and sealing gasket is not visible.
   - Main housing is flush with chassis and sealing gasket is not visible.

5. **Front Panel**
   - Keypad is not damaged or delaminated.
   - Text on LCD is aligned evenly with keypad window (i.e., LCD is not crooked).
   - LCD is free of cracks.

6. **Lower Housing**
   - Housing is securely attached.
   - Housing is intact and free of cracks.
   - Lower housing clips are intact.
   - Chassis mounts are intact.

7. **Mechanisms and Sensors**

   First, clamp instrument to a table, remove lower housing, and rotate instrument so that the pumping mechanisms are on top. Ensure the following:

   - Air-in-line sensor modules are attached securely.
   - Air-in-line sensor tubing recess is thoroughly cleaned.
   - Slide links are clean and move freely.
   - Pump latch assemblies are intact and springs seated properly.
   - Pump latch assemblies open and close with a firm snap.
   - Pump shaft seals are seated.
   - Valve actuator tips are not damaged.
   - Valve actuator seals are not damaged and are seated properly.
   - Pressure transducers are seated and their tape covers intact.

B. Cleaning

If inspection indicates cleaning is needed, refer to section 4.1. Always clean before completing the remaining preventive maintenance procedures. This ensures that the sensors are clean and dry before calibration.

C. Retrieving the Event Log

Refer to the FMS Directions For Use manual for complete instructions.

1. Attach the RS-232 communications cable from the PC to the instrument COMM port.
2. Sign on to FMS. Select the Event Log command from the Main Menu, and then store the Event Log to a file.
3. View or print the event log. Inspect Event Log for watchdogs, faults or other system errors. Refer to Chapter 6, Troubleshooting, for details on interpreting the Event Log.

D. Checking Memory Backup Battery

A lithium primary cell backs up memory and powers the RTC when the instrument is turned off. This battery should be replaced every five years. The installation date is displayed on the Battery History Log page (date is in the top line on the right-hand side, refer to Appendix D).

The Battery History Log is accessed by the BATLOG softkey. The BATLOG soft-key is displayed by pressing the MoreOptions key while on the Standard Display page (software version 3.2 and higher). Refer to Repair, section 7.0, for instructions on replacing the backup battery.

NOTE: *Memory contents will be lost during replacement of the lithium backup battery, so this step should be performed after retrieving the Event Log and before calibrating the instrument.*

E. Verifying Proper Software Version, Serial Number, and Customized Settings

Verify that the software version installed in the instrument is appropriate by viewing either the Instrument Information page during power-up, or the Model 2860 I.D. page and Model 2863 Configuration pages 4 and 5 that is available when the MORE OPTIONS key is used.

Determine the serial number stored in instrument memory. This can be read from either the Instrument Information page or the I.D. page. If the serial number is not the same as the number on the rear label of the instrument, use FMS to enter the correct number (refer to FMS Manual for details).

Verify that the instrument settings which your institution has chosen to customize are configured properly. Refer to the FMS Manual.

F. Calibration

Annual calibration is recommended to account for any wear or drift in the sensor systems. These sensor systems include cassette/latch, patient-side occlusion, and fluid-side occlusion. Be sure that the sensors are clean and dry before recalibrating. Refer to Chapter Five for calibration procedures.

G. Functional Tests

Functional tests are recommended to verify that the instrument is performing within specifications. Refer to Chapter Three for detailed procedures. These functional tests include the following.

- Electrical safety
- Power-up
- Cassette/latch sensor
- Patient-side occlusion detection
- Fluid-side occlusion detection
- Air-in-line detection
- Battery operating time
- Volume accuracy
- Watchdog audio (software versions 3.3 and higher)
- Communications

H. Reprogram Special Note Page (Optional)

The optional Special Note page may be used to provide a reminder of when the next annual maintenance is due, or any other message of up to five lines of text. When this function is enabled, this page will be displayed on the date programmed. The Special Note page can also be used to program up to five lines of user text which will be displayed after the Instrument Information page, during instrument power-up. To enable this function, use FMS. Set the notification date, and enter up to five lines of text. Refer to the FMS Manual for detailed programming instructions.

TABLE OF CONTENTS

NOTES:

Chapter 5
Calibration

5.0 Introduction

Differences among instrument components (e.g., transducers, mechanical components, circuit gains and offsets) necessitate the calibration of certain systems. These systems detect cassette installation, latch closure, patient-side occlusions, and fluid-side occlusions.

Software functions are used to perform instrument calibrations. Calibration is required after replacing certain components as a part of preventive maintenance, or if memory contents are corrupted. Refer to chapter 6 for help in Troubleshooting calibration failures.

Refer to the appropriate Field Maintenance Software Directions For Use for calibration information for your version of FMS software.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

Chapter 6
Troubleshooting

6.0 Introduction to Troubleshooting

6.1 General Guidelines

Before beginning any troubleshooting on the MedSystem III instrument, it is recommended that service personnel review and be familiar with the following information.

1. Operation of the MedSystem III Infusion System (Refer to the MedSystem III Infusion System Directions For Use.)
2. Operation of Field Maintenance Software (Refer to the Field Maintenance Software Directions for Use (FMS DFU).)
3. The following chapters in this Technical Manual:

    Principles of Operation (Chapter 2)
    System Functional Tests (Chapter 3)
    Calibration (Chapter 5)
    Repair (Chapter 7)

Troubleshooting the MedSystem III instrument can best be accomplished by replacing questionable parts or modules with parts or modules that are known to be good. Due to the construction techniques and equipment used to manufacture the instrument, many of the parts cannot be serviced in the field and must be replaced on a modular level. The replacement parts needed during troubleshooting are listed in Appendix C. Contact your sales representative or the Customer Service Department for further information on how to obtain these parts.

> **NOTE:** *Due to potential incompatibility, it is recommended that parts not be removed from other instruments for use as replacements.*

Technical bulletins are published periodically to supplement this manual. If a problem cannot be readily resolved using this manual or the bulletins, contact the Clinical Engineering Department for further information.

6.2 Types of Problems Encountered

6.2.1 Operator Error

Potential operator errors that might be confused with hardware problems are discussed in the troubleshooting guides. These errors are generally the first possible cause listed, since verification does not require instrument disassembly.

6.2.2 Environmental Interference

The MedSystem III intrument is designed to withstand typical environmental conditions encountered during normal use, including electromagnetic interference, mechanical shock, and temperature extremes. Possible sources of electromagnetic interference include electrosurgical units, diathermy units, portable x-ray equipment, radio interference, and electrostatic discharge. Occasionally, however, a condition that exceeds instrument specifications may occur and interfere with

operation. Errors are quickly detected by self-test functions, resulting in an advisory, an alarm, a fault, or a watchdog.

6.2.3 Hardware Defects

If a problem consistently repeats in the Event Log and is reproducible during testing, then it is most likely a defect in the hardware.

6.2.4 Intermittent Defects

If a problem consistently repeats in the Event Log but cannot be reproduced during testing, it is most likely an intermittent defect. Connectors can be the source of intermittent problems.

6.2.5 Troubleshooting Procedures

a. Physical Inspection

Certain defects can be determined by inspecting the instrument. Refer to diagrams in Appendix E for names of parts and layout. Inspect the items listed below prior to troubleshooting, disassembling, or repairing. Verify that the following conditions exist.

1. AC Adapter:

- AC power and ground prongs are not damaged or loose.
- Housing is intact, free of cracks, and the side of the case is not bulged or dimpled.
- Cable insulation is intact and not frayed or cut.
- Instrument connector shell is intact and pins are not damaged.

2. Pole Clamp:

- Housing is not broken or cracked.
- Instrument front-to-back indexing is firm.
- Clamp rotates properly around the bracket.
- Clutch operates and is adjusted properly.
- Rubber pads are intact.

3. Loose Parts:

- Shake the instrument to ensure there are no loose internal parts.

4. Main Housing:

- There are no significant cosmetic defects.
- Labels are intact.
- Main housing is intact and free of cracks.
- Connector dust caps are intact and free of cracks.
- Battery pack is flush with top of case and sealing gasket is not visible.
- Main housing is flush with chassis, and sealing gasket is not visible.

5. Front Panel:

- Keypad is not damaged or delaminated.
- Text on LCD is evenly aligned with keypad window (i.e., LCD is not crooked).
- LCD is free of cracks.

6. Lower Housing:

- Housing is securely attached.

- Housing is intact and free of cracks.
- Lower housing clips are intact.
- Chassis mounts are intact.

7. Mechanisms and Sensors:

   First clamp instrument to a table, remove lower housing, and rotate so that the pumping mechanisms are on top. Ensure the following conditions exist.

- Air-in-line sensor modules are attached securely.
- Air-in-line sensor tubing recess is thoroughly cleaned.
- Slide links are clean and move freely.
- Pump latch assemblies are intact and springs seated properly.
- Pump latch assemblies open and close with a firm snap.
- Valve actuator tips are not damaged.
- Valve actuator seals are not damaged and are seated properly.
- Pressure transducers are seated and their tape covers intact.

b. Power-up the Instrument

Turn on the instrument by pressing the ON key. If it does not turn on, refer to Troubleshooting Table 6-2.

> NOTE: *If possible, retrieve the Event Log (see step C) before performing any troubleshooting that requires PCBA replacement.*

If the instrument does turn on, record the operating parameters on a data sheet.

c. Retrieve and Examine the Event Log

The instrument stores information that is useful for troubleshooting and documenting normal operation. This includes watchdogs, faults, and other significant events encountered during operation, service, calibration, and customizing of operational parameters. Field Maintenance Software is used to retrieve, display, and print the Event Log. Refer to the FMS Manual for details on operating FMS.

d. Reproduce the Problem

If possible, simulate the operating conditions at the time the problem occurred. When the operating conditions are not known, perform the functional tests described in Chapter 3, and operate the instrument.

Suggested settings are a rate of 125 ml/h for one hour and 999 ml/h for one hour.

e. References

Use the reference guides in the following section (6.3) to determine the appropriate troubleshooting table.

6.3 Troubleshooting References

Troubleshooting tables are provided for isolating the causes of watchdogs, faults, false alarms, advisories, performance that is not within specification, and several other types of functional problems. The following list provides the table numbers and titles.

Reference lists are provided in the following sections. Event codes used in these lists are either obtained from the Event Log, using FMS, or they are displayed during power-up on the User Information Line of the Instrument Information page (see Directions For Use).

6.3.1 Watchdogs

- Event codes 0 to 255 are watchdogs. Most watchdog codes are for use in factory analyses and are not described in detail in this manual.
- For failures during power-up, refer to Table 6-2.
- For watchdogs after power-up, refer to Table 6-3.
- For general watchdog categories, refer to Table 6-4.

6.3.2 Faults

Code	Description	Reference Table
256	System error	6-7.1
257	Drug name out of range	6-9.9
258	Drug calculation error	6-9.9
259	Motion sensor error	6-11
260	Encoder error	6-11
261	Data range error	6-9.9
262	Data range error	6-9.9
263	Pressure calibration required	6-8.1
264-269	Display Module LED failure	6-9.5
270	Pressure sensor error	6-14.3
272	Cassette calibration required	6-8.1
273	Motion sensor error	6-11
274	Pump motion error (Rev. 3.2a only)	6-12.4
275	Pump does not home	6-12.5
276	Fluid-side occlusion calibration required	6-8.1
277	Pump motion hindered	6-12.6
278	Drive system error	6-12.8
279	System error (Vers. 3.2a only)	6-7.2
280	Pressure sensor error	6-14.3
281	Encoder error	6-11
282	Pump motion hindered	6-12.7

6.3.2 Faults (continued)

Code	Description	Reference Table
283	Pump motion hindered	6-12.7
286	Air sensor error	6-13.4
287	Air sensor error	6-13.4
288	Air sensor error	6-13.4
289	Encoder error	6-11
290	Encoder error	6-11
291	System error (Rev. 3.2a only)	6-7.3
292	Latch out of order	6-10.3
293	Cassette sensor error	6-10.6
294	Air sensor error	6-13.4
295	Air sensor error	6-13.4
296	Encoder error	6-11
297	Drive system error	6-12.8
298	Drive system error	6-12.8
299	Drive System error	6-12.8
300	EPROM error System error	6-3
301	Timebase error System error	6-3
302	Voltage error System error	6-3
303	Voltage error System error	6-3
304	EPROM error System error	6-3
305	Voltage error System error	6-3
306	System error	6-3
307	System error	6-3
308	System error	6-3
309	System error	6-3
310	Parameter Range error	6-7.6
311	Power System Failure	6-7.5
312	Parameter Range error	6-7.6
313	System Inconsistency	6-7.6
314	System Inconsistency	6-7.6
315	System Inconsistency	6-7.6
316	System Inconsistency	6-7.6
317	System Inconsistency	6-7.6
318	System Inconsistency	6-7.6
319	System Inconsistency	6-7.6
320	System Inconsistency	6-7.6
321	System Inconsistency	6-7.6
322	System Inconsistency	6-7.6
323	System Inconsistency	6-7.6
324	System Inconsistency	6-7.6
325	System Inconsistency	6-7.6

6.3.3 Significant Events

Code	Description	Reference
514	Keypad error	Table 6-9.2
528	Communications error	Table 6-5.3
529	Initialization	Section 6.4.2
530-531	Normal use	Section 6.4.1
532	Parameters configured	Section 6.4.5
533	Initialization	Section 6.4.2
534	Power system failure	Table 6-7.4

6.3.3 Significant Events (continued)

Code	Description	Reference
536-543	Parameters configured	Section 6.4.5
553-560	Normal use	Section 6.4.1
561	Parameters configured	Section 6.4.5
568	Event Log related	Section 6.4.3
569-574	Calibration	Section 6.4.4
575	Cassette & latch calibration	Table 6-8.3
576	Cassette & latch calibration	Table 6-8.3
577	Fluid-side occlusion	Table 6-8.5
578	Fluid-side occlusion	Table 6-8.5
579	Pressure calibration	Table 6-8.2
580	Pressure calibration	Table 6-8.2
582-583	Parameters configured	Section 6.4.5
592	Software version changed	------
593	Event Log related	Section 6.4.3
594-604	Parameters configured	Section 6.4.5

6.3.4 Alarms, Advisories, and Notifications

Description	Reference
Air in line	Table 6-13
Air in lower tubing	Directions For Use
Cassette jammed	Table 6-12.3
Cassette not latched	Table 6-10.2
Cassette removed	Table 6-10.4
Check air sensor	Tables 6-13.1,2
Faulty cassette	Table 6-10.6
Fluid-side occluded	Table 6-15
Install cassette	Table 6-10.5
Patient-side occluded	Table 6-14
Pump latch closed	Table 6-10.3
Power system failure	Table 6-7.4
Push slide clamp in	Table 6-10.1

6.3.5 Performance Out of Specification

Description	Reference
Air-in-line detection	Table 6-13.3
Battery operating time	Table 6-6
Fluid-side occlusion detection	Table 6-15.2
Ground continuity	Table 6-1.3
Leakage current	Table 6-1.2
Patient-side occlusion detection	Table 6-14.1,2
Volume accuracy	Table 6-12.2

6.3.6 Other Conditions

Description	Reference
Audio	Table 6-9.3,4
Calibration out of limits	Table 6-8.2-5
Cassette installation	Table 6-12.1
Communications	Table 6-5
Fails normal power-up	Table 6-2
Instrument will not shut off	Table 6-16
Keypad	Table 6-9.1

6.3.6 Other Conditions (continued)

Description	Reference
LCD	Table 6-9.6 - 8
LED and external power	Table 6-1.1
LED (Display Module)	Table 6-9.5
Pump shutoff: low power	Directions For Use
Pump does not home (without Code 275 fault)	Table 6-11.9
Pump shutoff: not in use	Directions For Use
Pump shutoff: Watchdog demo	Directions For Use

6.4 Event Codes Recorded During Normal Use

6.4.1 Operating Events

530 Setup Line Enabled or Disabled:

If setup is enabled, then the setup line appears on the pump channel page (see Directions For Use). This feature allows the user to program an infusion, using either Volume and Rate or Volume and Time (for more information, see the Directions For Use). If setup is disabled, then only Volume/Rate infusions can be set, and the setup line does not appear on the pump channel page.

531 Device Type Changed:

This code is logged whenever the Device Type is changed. Secondary data indicates the selected Device Type.

Device Type	Secondary Data
General purpose	0
Neonatal	1
Controller pressure	2
Operating room	3
General purpose II	4
Operating room II	5

553 - 560 Time and Date Changed

Whenever the user changes the time, day, month, or year, two codes are associated with each parameter change. The first code indicates what the parameter setting was prior to the change, and the second code indicates the setting after the change.

Code	Parameter Setting
553	Time changed: previous value
554	Time changed: current value
555	Day changed: previous value
556	Day changed: current value
557	Month changed: previous value
558	Month changed: current value
559	Year changed: previous value
560	Year changed: current value

6.4.2 Initialization

529 RAM initialization:

Shorting the two pads on the top interconnect board initializes the RAM space. This is generally performed when an instrument is reassembled, or when memory is corrupted.

533 Partial RAM initialization:

Certain data structures in RAM space are initialized when faults or infusion parameters are reset using FMS. Fault resets are indicated by a secondary data value of 32, and infusion parameter (e.g., volume remaining and rate) resets by a 1.

6.4.3 Event Log Related

568 Event Log entry corrupted:

A data integrity check is performed on each Event Log entry. Should the data become corrupted, this code replaces the initial code. It is not possible to recover the particular Event Log entry when this has occurred.

593 Event Log cleared:

This code indicates the Event Log was cleared with FMS.

6.4.4 Calibration

Calibration is documented in the Event Log by the codes in the following list. Numbers 569 through 574 indicate that a calibration step was performed for a particular channel. Thus, complete calibration of an instrument will result in 18 Event Log entries.

Code	Calibration Out of Limit
575	Cassette and latch sensor, Step 1
576	Cassette and latch sensor, Step 2
577	Fluid-side occlusion, Step 1
578	Fluid-side occlusion, Step 2
579	Patient-side occlusion, calibration zero
580	Patient-side occlusion, calibration slope

6.4.5 Parameters Configured

Certain instrument functions may have been customized either by an authorized MedSystem representative or by the customer through the use of FMS. The following event codes describe what parameters are customized. Refer to the FMS Directions For Use Manual for additional information on configuring parameters. If a command is not listed, then the parameter could not be set with FMS at the time this manual was published.

Code	Parameters
532	Maximum pressure limit
536	Pressure increment
537	Maximum volume remaining
538	Maximum rate
539	KVO rate
540	Air-in-line sensitivity
541	Device Type change lockout enabled or disabled
542	High resolution rate enabled or disabled (for software versions prior to 3.1 series)
543	ALL mode enabled or disabled
561	ON/OFF key holding time to turn pump off
582	Audio volume ramping
583	MaxFSO function enabled or disabled
594	ClrAir function rate range
595	ClrAir function enabled or disabled
596	ClrAir function maximum number

Code	Parameters (Cont.)
598	Clear Secondary VR, if off >5 min
604	Fractional scrolling breakpoint

Secondary data, which is dependent on the software version in use, indicates the selected Device Type. The parameters for each Device Type must be customized separately.

Device Type	Secondary Data
General purpose	0
Neonatal	1
Controller pressure	2
Operating room	3
General purpose II	4
Operating room II	5

Table 6-1. External Power Problems

Symptom	Possible Cause and Action
1. External power LED off (see side panel).	**A. AC power not applied to the adapter** • Ensure that AC adapter is properly plugged into an AC outlet. • Verify that the wall outlet is functioning. **B. AC adapter not connected to instrument** • Ensure that AC adapter is properly connected to the instrument. **C. Defective AC adapter** • Test AC adapter with AC adapter tester. • The definitions for the LED symbols are Power: ⎓ Ground: ⏚ Grounded Shield: ⊜ • Verify that all LEDs are illuminated. • If any LEDs are not illuminated, AC adapter is defective and must be replaced. If LEDs are illuminated, proceed to next step. • Verify that output signal on oscilloscope is within the range of 6 to 10 VDC with a maximum ripple voltage of 1.5 Vp-p. • If voltage is out of range, AC adapter is defective and must be replaced. **D. Defective audio/connector PCBA** • Ensure that connectors to power supply for MA are properly seated. • Test with a replacement audio/connector PCBA. • If problem does not repeat, replace suspect PCBA. **E. Defective power supply PCBA** • Disconnect the power supply connector for the audio/connector PCBA. If external power LED turns on, power supply PCBA is defective. **F. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. Leakage current greater than 100 μA.	**A. Incorrect leakage current test procedure** • Refer to the test equipment manual for proper procedure. **B. Defective AC adapter** • Replace AC adapter.
3. Ground continuity greater than 0.1 ohms.	NOTE: To minimize contact and lead resistances, measure the following resistances with a four-wire ohmmeter. **A. Black-coated chassis** • The black coating is an insulator. Measure ground continuity from the bare metal test point located toward the rear of the instrument underneath the lower housing (see Chapter Three). **B. Aluminimum chassis** • The test point can be any location. (Table continued next page)

Table 6-1. External Power Problems (Cont.)

3. Ground continuity greater than 0.1 ohms. (continued)	**C. AC adapter connector grounding defective** • With the AC adapter attached to the MedSystem III, measure resistance from connector body to AC adapter ground pin. • If greater than 0.1 ohms, replace AC adapter. **D. Audio/Connector PCBA grounding defective** • Measure resistance from A/C nut to-AC adapter ground pin. • If greater than 0.1 ohms, replace audio/connector PCBA. **E. Defective connection on the chassis** • Remove screw holding green ground wire to the chassis. • Clean surface and lug terminal. • Reinstall lug and screw. **F. Defective connection on power supply PCBA.** • Replace power supply PCBA when the above procedures fail to indicate the source of the problem.

Table 6-2. Fails Normal Power-up

Symptom	Possible Cause and Action
1. Totally unresponsive (no audio, LEDs, LCD).	**A. Fuse blown and no external power** • Attach AC adapter power and charge the battery for 1 hour. • Turn instrument on. • Remove external power. • If instrument turns off, the fuse is blown. • Replace fuse. **B. Battery voltage low and no external power** • Attach AC adapter power and verify external power LED is ON. If not, refer to Table 6-1. • If on, charge battery for 1 hour and retry. • Try again to turn on the instrument. • If instrument turns on normally, then charge for 13 hours. **C. Defective internal connection** • Reseat top interconnect board, keypad, power board and audio/connector PCBA connectors. **D. Defective battery** • Replace suspect battery with a replacement battery. • Charge for 1 hour. If instrument turns on, replace suspect battery. **E. Defective keypad** • Remove main housing and test with replacement case. • Replace case if defective. **F. Defective power supply PCBA** • Test with a replacement power supply PCBA. If instrument turns on normally, suspect power supply is defective and must be replaced. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. Watchdog occurs during power-up.	**A. Battery depleted and no external power** • Attach AC adapter power and verify external power LED is on. If not, refer to Table 6-1. • If on, charge battery for 1 hour. • Try again to turn on instrument. • If instrument turns on normally, charge battery for 13 hours. **B. Fuse blown and no external power** • Attach AC adapter power and charge the battery for 1 hour. • Turn on instrument and remove external power. • If instrument turns off, the fuse is blown. • Replace fuse. **C. Event Code 40: Pump latch moved during motor path self-test on power-up** • Verify by repeating ON/OFF sequence several times with no cassette in place. • If Event Code 40 repeats, replace MEA. • If Event Code 40 does not repeat, it is likely that the pump latch was moved manually during self-test. **D. Event Code 30: Range error** • Use FMS to reset infusion parameters. • If this event code repeats, initialize RAM by jumpering the RAM initialization solder pads. Refer to Chapter 7.

(Table continued next page)

Table 6-2. Fails Normal Power-up (Cont.)

2. Watchdog occurs during power-up. (continued)	**E. EPROM missing, inserted improperly, or defective** • Remove battery pack and inspect EPROM. • Reseat if not properly installed. • Replace if properly installed and still fails to operate. **F. Top interconnect board not seated** • Reseat top interconnect board. **G. Power supply connector not seated** • Reseat four-wire connector from power supply to audio/connector PCBA. **H. Defective power supply PCBA** • Test with a replacement power supply PCBA. If instrument turns on normally, suspect power supply is defective and must be replaced. **I. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
3. LEDs and audio work, but no LCD message.	**A. Top board interconnect not seated.** • Remove battery pack and reseat top interconnect board. **B. Defective LCD** • Test with replacement LCD module. • Replace LCD module if defective. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-3. Watchdogs After Powerup

Symptom	Possible Cause and Action
1. Any Watchdog code (isolated occurrenc-es).	**A. System error discovered after publication of this manual.** • Review Technical Service Bulletins, or contact the Technical Service Dept. for the latest information. **B. Top interconnect board not seated** • Remove battery pack and reseat top interconnect board. **C. Fuse blown and no external power** • Attach AC adapter power and charge the battery for 1 hour. • Turn on instrument. • Remove external power. • If instrument turns off, the fuse is blown. • Replace fuse. **D. Environmental interference** • Refer to section 6.1.2.
2. Event Code 51	**A. Pump latch moved while instrument is not infusing** • Turn on instrument and check for movement. • If no movement occurs, the latch may have been moved manually. • If movement occurs, replace MEA.
3. Event Codes 21, 25, 26, 27 300*, 304*	**A. Defective EPROM** • Replace EPROM module.
4. Repeated occurrenc-es of any Watchdog.	**A. System error discovered after publication of this manual** • Review Technical Service Bulletins, or contact the Technical Service Dept. for the latest information. **B. Top interconnect board not seated** • Remove battery pack and reseat top interconnect board. **C. Fuse blown and no external power** • Attach AC adapter power and charge the battery for 1 hour. • Turn on instrument. • Remove external power. • If instrument turns off, the fuse is blown. • Replace fuse. **D. Defective power supply PCBA** • Test with a replacement power supply PCBA. If instrument turns on normally, suspect power supply is defective and must be replaced. **E. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

* These codes are not watchdogs; they are non-resumable faults caused by the occurrence of a particular watchdog.

Table 6-4. Quick Reference Watchdog List

Symptom	Possible Cause and Action
30	**Data Handling** • Cycle power to reset pump. If WD continues, return pump to IVAC.
72, 95, 96	**Air-in-line** • Cycle power. If WD continues, return pump to IVAC.
94	• Replace MEA board.
49	**Encoder** • Cycle power. If WD continues, return pump to IVAC.
16, 35 (Rev. 3.3d only)	**Infusion Control** • Cycle power to reset pump. If WD continues, return pump to IVAC.
17, 39, 56	**Motor** • Cycle power to reset pump. If WD continues, return pump to IVAC.
40	• Replace drive module.
47, 48 (Rev. 3.3d only), 67 302*, 303*, 309*	• Replace power board.
51, 98 306*	• Replace MEA board.
88 305*	• Replace power board or MEA board.
101 307*	**13V Power Supply Voltage is Greater than 13V** • Substitute known good MEA board. If this does not fix problem, replace power board.
102 308*	**5V Power Supply Voltage is Greater than 5V** • Substitute known good MEA board. If this does not fix problem, replace power board.
75, 77, 79, 80, 81, 82, 85, 89, 90, 91, 97, 99, 100	**Power On Self-Test** • Replace MEA board.
83, 86	• Replace power board.
87	• Replace power board or MEA board.
22, 23, 42, 43, 44, 46	**Watchdog Control** • Cycle power. If WD continues, return pump to IVAC.
45, 84	• Replace MEA board.
6, 9, 10, 41, 50, 58, 59	**System Task** • Cycle power. If WD continues, return pump to IVAC.
24, 37 301*	**Timing** • Replace MEA board.

(Table continued next page)

Table 6-4. Quick Reference Watchdog List (Cont.)

0, 1, 2, 7, 33, 52	**General System** • Cycle power. If WD continues, return pump to IVAC.
70, 73 304*	• Replace EPROM.
4	**A-to-D** • Cycle power. If WD continues, return pump to IVAC.
5	• Replace MEA board.
8, 11, 12, 13, 14, 15, 32, 34, 60, 61, 62, 63, 64, 65, 66, 68, 78	**Hardware** • Replace MEA board.
21, 25, 26, 27	• Replace EPROM.
31	• Cycle power. If WD continues, return pump to IVAC.
57	**Defective Keypad** • Replace Main Housing. If problem repeats, replace MEA board.
18, 19, 28, 38	**Miscellaneous** • Cycle power. If WD continues, return pump to IVAC.
92, 93	• No problem. Information in event log only.

* These codes are not watchdogs; they are non-resumable faults caused by the occurrence of a particular watchdog.

Table 6-5. Communications Inoperable

Symptom	Possible Cause and Action
1. The FMS does not communicate with any MedSystem III instrument.	**A. Cables not connected** • Ensure PC cable connectors are properly seated. **B. The FMS not configured for present communications port in the PC** • Refer to the FMS Instructions. **C. Pump not in Clinical Configuration Mode** • Refer to the FMS and the Directions For Use. **D. Communications cable defective** • Retry with a replacement cable. **E. Defective serial port for the FMS computer** • Retry with a replacement serial card.
2. The FMS does not communicate with a specified MedSystem III instrument.	**A. Audio/connector PCBA connector not seated** • Reseat ribbon cable connector to MEA. **B. Defective audio/connector PCBA.** • Ensure that connectors to power supply for MEA are properly seated. • Test with a replacement A/C PCBA. • If problem does not repeat, replace suspect PCBA. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
3. Event code 528	**A. System error** • This code indicates that an internal error occurred during communications. Contact the Clinical Engineering Department for further information.

Table 6-6. NiCd Battery Problems

NOTE: Before troubleshooting, perform a complete battery performance test (see Chapter 3).

- T_{LB1} is the time interval from full charge to low-battery advisory.
- T_{LB2} is the time interval from low-battery advisory to battery-depleted alarm.
- T_{total} is the sum of T_{LB1} and T_{LB2}.

Symptom	Possible Cause and Action
1. Sufficient capacity (T_{total}>6h) but premature low-battery advisory (T_{LB1} <5.5h).	**A. Storage at extremes of temperature specifications** • Storage at elevated temperatures between 35°C and 55°C can degrade performance. If the exposure time is for under a week, some recovery is possible, but only after several complete charge/discharge cycles at room temperature. (Operate instrument past battery-depleted to shut off, then recharge for 14 hours.) Storage for more than 3 months should be at temperatures below 35°C; otherwise, permanent damage can occur. **B. Operation at extremes of temperature specifications** • NiCd battery capacity is maximum at room temperature and is significantly reduced at temperatures above 35°C. Exposure to high temperatures for a short time will not cause permanent damage; and, capacity will recover after several complete charge/discharge cycles at room temperature. (Operate instrument past battery depleted to shut off, then recharge for 14 hours.) **C. Battery voltage depression effect** • Repeated shallow discharge or extended AC charging of NiCd batteries can cause a temporary depression in the voltage discharge characteristics. Several complete charge/discharge cycles reverse this condition. (Operate instrument past battery depleted to shut off, then recharge for 14 hours.) **D. Defective battery** • Test with a charged replacement battery and repeat battery operating advisory test. • If problem does not repeat, then the suspect battery is defective and must be replaced. **E. Defective power supply PCBA** • Test with a charged replacement battery. **F. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. (Table continued next page)

Table 6-6. NiCd Battery Problems (Cont.)

2. Inadequate Capacity (T_{total} <6h).	**A. Battery not charged due to external power problem** • Refer to Table 6-1. **B. Storage at extremes of temperature specifications** • Storage at elevated temperatures between 35°C and 50°C can degrade performance. If the exposure time is for under a week, some recovery is possible, but only after several complete charge/discharge cycles at room temperature. (Operate instrument past battery-depleted to shut it off, then recharge for 14 hours.) Storage for more than 3 months should be at temperatures below 35°C; otherwise, permanent damage can occur. **C. Operation at extremes of temperature specifications** • NiCd battery capacity is maximum at room temperature and is significantly reduced at temperatures above 35°C. Exposure to high temperatures for a short time will not cause permanent damage; and, capacity will recover after several complete charge/discharge cycles at room temperature. (Operate instrument past battery-depleted to shut it off, then recharge for 14 hours.) **D. Defective battery** • Test with a charged replacement battery and repeat battery operating-time test. • If problem does not repeat, suspect battery is defective and must be replaced. **E. Defective power supply PCBA** • Test with replacement power supply PCBA. • If problem does not repeat, suspect battery is defective and must be replaced. **F. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-7. System Faults

Symptom	Possible Cause and Action
1. Event code 256: System error.	**A. Defective watchdog circuit** • If problem repeats, replace MEA.
2. Event code 279: System error (Software version 3.2a only).	**A. Corrupted RAM contents** • Reinitialize RAM by jumpering RAM initialization solder pads. Refer to Chapter 7. **B. Defective memory circuit** • If problem repeats, replace MEA.
3. Event code 291: System error (Software version 3.2a only).	**A. Internal date corrupted** • Software indicates that data is corrupted. If you suspect that the corruption was not due to environmental interference, contact the Clinical Engineering Department.
4. Event code 534: Internal Charger fault.	**A. Defective battery** • Test with a replacement battery. • Charge for 1 hour with instrument off. • With AC power attached, turn the instrument on and operate overnight (at least 10 hours) with a cassette in at least one channel. The channel with the cassette does not need to be infusing, but should be placed on STANDBY. • If problem does not repeat, suspect battery is defective and must be replaced. **B. Defective power supply PCBA** • Test with replacement power supply PCBA. • Charge for 1 hour with instrument off. • With AC power attached, turn the instrument on and operate overnight (at least 10 hours) with a cassette in at least one channel. The channel with the cassette does not need to be infusing, but should be put on STANDBY. • If problem does not repeat, suspect power supply is defective and must be replaced. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. (Table continued next page)

Table 6-7. System Faults (Cont.)

5. Event code 311: Power system failure.	**A. Defective battery** • Test with a replacement battery. • Charge for 1 hour with instrument off. • With AC power attached, turn the instrument on and operate overnight (at least 10 hours) with a cassette in at least one channel. The channel with the cassette does not need to be infusing, but should be placed on STANDBY. • If problem does not repeat, suspect battery is defective and must be replaced. **B. Defective power supply PCBA** • Test with replacement power supply PCBA. • Charge for 1 hour with instrument off. • With AC power attached, turn the instrument on and operate overnight (at least 10 hours) with a cassette in at least one channel. The channel with the cassette does not need to be infusing, but should be put on STANDBY. • If problem does not repeat, suspect power supply is defective and must be replaced.
6. Event Codes 310, 312 - 325	**A. General System Error** • If pressing RETRY does not solve the problem or if the error is occurring repeatedly, contact the Clinical Engineering Department for further information.

Table 6-8. Calibration Problems

Symptom	Possible Cause and Action
1. Event code 263: Pressure calibration required. Event code 272: Cassette and latch sensor calibration required. Event code 276: Fluid-side occlusion detection calibration required.	**A. Calibration not performed (software versions prior to 3.2)** • Recalibrate the instrument, using FMS (refer to Chapter 5). **B. Calibration not performed correctly (software version 3.2 and above)** • Recalibrate the instrument, using FMS (refer to Chapter 5). **C. Backup battery not connected or depleted** • Measure Vback at backup battery connector. • If less than 2.5V, replace battery. **D. Defective memory backup circuits on MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. Event codes 579 & 580: Pressure calibration (zero or slope) not within limits.	**A. Calibration not performed correctly** • Recalibrate the instrument, using FMS. • Ensure that proper pressure is applied (refer to Chapter 5). **B. Pressure connector loose** • Remove main housing and LCD. • Reseat pressure transducer connector. **C. Defective pressure transducer** • Inspect for broken wires. Replace transducer if wires are broken. • Using the pressure transducer jumper cable, connect the suspect transducer to a channel that operates properly. Recalibrate the replacement channel; but, apply pressure to the suspect transducer. If the problem recurs, replace the suspect transducer. **D. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
3. Event codes 575 & 576: Cassette and latch calibration.	**A. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step and that the pump latch is in the proper position. **B. Cassette or latch sensor dirty** • Clean optomodule sensors and slide link, using procedure described in Chapter 4. • Remove slide link, using procedures described in Chapter 7. • Inspect slide link reflector and replace if damaged. **C. Optomodule flex not seated in connector properly** • Reseat both flex cables. • Ensure that the two flex cables are properly positioned. **D. Defective optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. • If input signals are correct but output signals are incorrect, then replace the optomodule. **E. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. (Table continued next page)

Table 6-8. Calibration Problems (Cont.)

Symptom	Possible Cause and Action
4. Fluid-side occlusion calibration will not run or complete.	**A. Cassette and latch sensors must be calibrated first** • Repeat cassette and latch calibration, using FMS. **B. Defective calibration cassettes** • Check operation of piston. • A piston sleeve must not be used with this cassette. • Elastomeric valve area in the cassette must be removed. • Replace cassette if defective, and repeat calibration. **C. Defective calibration fixture** • Check calibration fixture function, using the procedure accompanying the fixture. **D. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that the pump latch does not bind with the side link. If it does, replace the pump latch or the slide link. **E. Motor and encoder connectors not seated** • Réseat connectors. **F. Defective drive module or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace the drive module. • Connect motor to a 5V power supply (red wire to positive), and verify that drive runs smoothly. • If motor does not operate, then replace. **G. Mechanical interference from the pump shaft** • Ensure that pump shaft bearings are properly seated. • Install a bearing clip, if missing. • Remove drive module and ensure that pump shaft moves smoothly. Clean and lubricate if necessary. **H. Mechanical interference from the valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. **I. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. (Table continued next page)

Table 6-8. Calibration Problems (Cont.)

Symptom	Possible Cause and Action
5. Event codes 577 & 578: Fluid-side occlusion calibration out of limits.	**A. Weights not applied in proper sequence** • Repeat calibration, using FMS. • Ensure weight fixture is vertical and weights are applied only when directed. **B. Defective calibration cassettes** • Check operation of piston. • A piston sleeve must not be used with this cassette. • Elastomeric valve area in the cassette must be removed. • Replace cassette, if defective, and repeat calibration. **C. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that the pump latch does not bind with slide link. If it does, replace the pump latch or slide link. **D. Defective drive module or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace the drive module. • Connect motor to a 5V power supply (red wire to positive), and verify that drive runs smoothly. • If motor does not operate, it must be replaced. **E. Mechanical interference from the pump shaft** • Ensure that pump shaft bearings are properly seated. • Install a bearing clip, if missing. • Remove drive module and ensure that pump shaft moves smoothly. Clean and lubricate, if necessary. **F. Mechanical interference from the valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-9. *User Interface Problems*

Symptom	Possible Cause and Action
1. Keypad does not respond.	**A. Keypad connector not seated** • Reseat connector. **B. Defective keypad** • Remove main housing. • Test with replacement keypad; if needed, replace keypad. **C. Defective audio/connector PCBA** • Disconnect audio/connector PCBA ribbon cable attached to the MEA and retry. • If problem does not repeat, replace audio/connector PCBA. **D. Defective decoder circuit on MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. Event code 514: Keypad system error.	**A. Defective keypad** • Remove main housing. • Test with replacement keypad; if needed, replace keypad. **B. Defective audio/connector PCBA** • Disconnect audio/connector PCBA ribbon cable attached to the MEA and retry. • If problem does not repeat, replace audio/connector PCBA. **C. Defective decoder circuit on MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
3. No audio output.	**A. Audio/connector PCBA ribbon cable connector not seated** • Remove battery pack. • Reseat ribbon cable connector to MEA. **B. Defective audio/connector PCBA** • Test with replacement audio/connector PCBA. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
4. No watchdog audio, but other audio tones all right.	**A. Defective MEA** • Replace MEA.
5. Event codes 264 - 269: Display module LED failure (green or red) or Display module LEDs do not turn on.	**A. Top interconnect board not seated** • Remove battery pack. • Reseat top interconnect board. **B. Defective display module** • Test with replacement display module. If needed, replace display module. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

(Table continued next page)

Table 6-9. User Interface Problems (Cont.)

Symptom	Possible Cause and Action
6. LCD is missing pixels.	**A. Defective display module** • Test with a replacement display module. If needed, replace display module.
7. LCD contrast is incorrect.	**A. Contrast not adjusted optimally** • Use the CNTRST softkey (VIEW in Model 2860) to adjust the display contrast (refer to Directions For Use). **B. Extreme temperature effects** • Allow instrument to equilibrate to room temperature. **C. Defective Keypad** • Test with replacement case. If needed, replace case. **D. Defective display module** • Test with a replacement display module. If needed, replace display module. **E. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

***WARNING:** Potential shock hazard with the backlighting.*

Symptom	Possible Cause and Action
8. Backlighting is out.	**A. Backlighting timed out** • Apply external power by attaching AC adapter. • Press STANDARD DISPLAY key and verify backlighting is on. • See Directions For Use for detailed instructions on backlight time out. **B. Backlight panel cable not connected** • Remove main housing and ensure backlight panel connector from power supply PCBA is properly seated. **C. Defective backlight panel** • Test suspect display module with a replacement display module. • If problem does not repeat, replace the backlight panel on the suspect display module. **D. Defective power supply module** • Test with a replacement power supply. • If problem does not repeat, suspect power supply is defective and must be replaced. **E. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
9. Event codes 261 & 262: Data range error. Event codes 257 & 258.	A. **Rate, volume, time combination out of command range** • Normally this can be resumed by the operator. • If the channel displays BIOMED in the Model 2860 or SERVICE in the Model 2863, use FMS to reset faults and initialize parameters. If the problem recurs, contact the Clinical Engineering Department.

Table 6-10. *Cassette and Latch Sensor Problems*

Symptom	Possible Cause and Action
1. *Push Slide Clamp In* advisory when START is pressed.	**A. Cassette slide clamp not pushed in all the way** • See Directions For Use for proper procedure. **B. Dirt in optomodule or slide link sensing area** • Clean optomodule, using procedure in Chapter 4. **C. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step, and that the pump latch is in the proper position. **D. Damaged slide link reflector** • Remove slide link, using procedure described in Chapter 7. • Inspect reflector and replace if damaged. **E. Optomodule flex not seated** • Remove main housing and expose optomodule flex connectors. • Inspect and reseat flex. Ensure that the flexes are centered properly. **F. Defective Optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. *Cassette Not Latched* alarm.	**A. Cassette slide clamp not pushed in all the way** • See Directions For Use for proper procedure. **B. Dirt in optomodule or slide link sensing area** • Clean optomodule, using procedure in Chapter 4. **C. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step, and that the pump latch is in the proper position. **D. Damaged slide link reflector** • Remove slide link, using procedure described in Chapter 7. • Inspect reflector and replace if damaged. **E. Optomodule flex not seated** • Remove main housing and expose optomodule flex connectors. • Inspect and reseat flex. Ensure that the flexes are centered properly. **F. Defective Optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

(Table continued next page)

Table 6-10. Cassette and Latch Sensor Problems (Cont.)

Symptom	Possible Cause and Action
3. Event code 292: Pump latch out of order or *Pump Latch Closed* alarm.	**A. Latch closed accidentally during cassette installation or removal** • If Biomed key was pressed, this results in Fault Code 292. • Manually open the pump latch. • Reset the fault, using FMS. • Perform cassette functional tests (see Chapter 3). **B. Dirt in optomodule or slide link sensing area** • Clean using procedures described in Chapter 4. **C. Cassette I.D. optics defective, dirty or wet** • Test with replacement cassette. • If problem does not repeat, the cassette optics may have been defective, dirty or wet. • Return defective cassettes to the Technical Service Dept. **D. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step, and that the pump latch is in the proper position. **E. Defective Latching Mechanism** • Remove lower housing. • Inspect slide link and pump latch for proper operation. **F. Damaged slide link reflector** • Remove slide link, using the procedure described in Chapter 7. • Inspect reflector and replace if damaged. **G. Optomodule flex not seated** • Remove main housing and expose the optomodule flex connectors. • Inspect and reseat flex. Ensure that the flexes are centered properly. **H. Defective Optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. • If input signals are correct but output signals are incorrect, replace the optomodule. **I. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. (Table continued next page)

Table 6-10. *Cassette and Latch Sensor Problems (Cont.)*

Symptom	Possible Cause and Action
4. *Cassette Removed* alarm.	**A. Dirt in optomodule or slide link sensing area** • Clean optomodule, using procedures described in Chapter 4. **B. Cassette I.D. optics defective, dirty or wet** • Test with replacement cassette. • If problem does not repeat, the cassette optics may have been defective, dirty or wet. • Return defective cassettes to the Clinical Engineering Department. **C. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step, and that the pump latch is in the proper position. **D. Damaged slide link reflector** • Remove slide link, using procedure described in Chapter 7. • Inspect reflector and replace if damaged. **E. Optomodule flex not seated** • Remove main housing and expose the optomodule flex connectors. • Inspect and reseat flex. Ensure that the flexes are centered properly. **F. Defective Optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. • If input signals are correct but output signals are incorrect, replace the optomodule. **F. Defective Optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. • If input signals are correct but output signals are incorrect, replace the optomodule. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

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Table 6-10. Cassette and Latch Sensor Problems (Cont.)

Symptom	Possible Cause and Action
5. *Install Cassette* advisory when START is pressed.	**A. Dirt in optomodule or slide link sensing area** • Clean using procedures described in Chapter 4. **B. Cassette I.D. optics defective, dirty or wet** • Test with replacement cassette. • If problem does not repeat, the cassette optics may have been defective, dirty or wet. • Return defective cassettes to the Clinical Engineering Department. **C. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step, and that the pump latch is in the proper position. **D. Damaged slide link reflector** • Remove slide link, using procedure described in Chapter 7. • Inspect reflector and replace, if damaged. **E. Optomodule flex not seated** • Remove main housing and expose the optomodule flex connectors. • Inspect and reseat flex. Ensure that the flexes are centered properly. **F. Defective Optomodule** • Measure input and output of the optomodule sensors, as described in Figures 6-1 and 6-2. • If input signals are correct but output signals are incorrect, replace the optomodule. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
6. Event code 293: Cassette sensor error or *Faulty Cassette* alarm.	**A. Dirt in optomodule or slide link sensing area** • Clean optomodule sensors, using procedures described in Chapter 4. **B. Cassette ID optics defective, dirty or wet** • Test with replacement cassette. • If problem does not repeat, the cassette optics may have been defective, dirty or wet. • Return defective cassettes to the Clinical Engineering Dept. **C. Calibration not performed correctly** • Recalibrate the instrument, using FMS. Ensure that cassettes are installed at the proper step, and that the pump latch is in the proper position. **D. Optomodule flex not seated** • Remove main housing and expose the optomodule flex connectors. Inspect and reseat flex. Ensure that the flexes are centered properly. **E. Defective optomodule** • Measure input and output of the optomodule, as described in Figures 6-1 and 6-2. • If input signals are correct but output signals are incorrect, replace the optomodule. **F. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-11. Encoder Faults

Symptom	Possible Cause and Action
1. Event codes 259, 260, 273, 281, 289, 290 and 296: Encoder or motion sensor error.	**A. Particles on the encoder disc or encoder sensor** • Remove battery pack, main housing and display module. • Remove cover from affected encoder. • Using clean, dry compressed air, blow disc and sensors clean. **B. Encoder connector loose** • Reseat connector. **C. Defective drive module clutch (Code 260 only)** • With display module removed, rotate drive cam to ensure that motion occurs only in one direction. • If motion occurs in both directions, replace drive module. **D. Defective drive module encoder** • Install primed cassette in affected channel • Attach display module to extender cable. • Attach test keypad and audio/connector PCBA. • Connect replacement test drive module by attaching jumper cables to suspect encoder. • Operate at the rate that the problem occurred, or 999 ml/h. • If problem does not repeat, replace the suspect drive module. **E. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-12. Drive System Errors

Symptom	Possible Cause and Action
1. Cannot install cassette.	**A. Pump latch not in home position** • Turn instrument off, then on. Verify that the pump latch moves to the home position (position closest to the chassis). • If instrument does not home, refer to Symptom 9 of this table. **B. Pump latch unable to open due to dried solution in slide link or pump latch area** • Use cleaning procedures described in Chapter 4. **C. Mechanical damage** • Check that the pump latch opens and closes properly. • Check for loose cassette guide or air-in-line sensor module. • Replace any damaged components.
2. Volume accuracy performance out of specification.	**A. Test method error** • Refer to Chapter 3 for proper test method. • Ensure that the glassware has sufficient precision. • Verify that timing during test is performed accurately. • Ensure that setup is free of air bubbles. **B. Cassette used beyond specification** • Replace cassettes every 48 hours. **C. Pump latch height not within specification** • Verify latch height, using procedures described in Chapter 7. **D. Valve actuator springs** • Disassemble instrument to expose valve actuators. • Verify valve actuators move smoothly. • Verify springs are properly positioned and free of grease. • Replace actuators and springs if defective. **E. Valve actuator height not within specification** • Verify valve actuator height, using procedures described in Chapter 7. • Replace drive module and valve actuators if not within specification.
3. *Cassette Jammed* alarm.	Remove cassette and turn power off, then on. If the drive homes properly, then use the following procedure; otherwise, follow the guide for Error Code 275, "Pump Does Not Home" (Symptom 5 of this table). **A. Cassette piston sleeve lifted** • Remove the cassette and reseat the piston sleeve. **B. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that pump latch does not bind with the slide link. **C. Pump latch height not within specification** • Verify latch height, using procedures described in Chapter 7. (Table continued next page)

Table 6-12. *Drive System Errors (Cont.)*

Symptom	Possible Cause and Action
3. *Cassette Jammed* alarm (continued).	**D. Defective drive module encoder** • Install primed cassette in affected channel. • Attach display module to extender cable. • Attach test keypad and audio/connector PCBA. • Connect replacement test drive module by attaching jumper cables to suspect encoder. • Operate at rate the problem occurred, or 999 ml/h. • If problem does not repeat, replace the suspected drive module. **E. Defective drive module mechanism or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace the drive module. • Connect motor to a 5V power supply (red wire to positive) and verify that the drive runs smoothly. • If motor does not operate, it must be replaced. **F. Mechanical interference from the pump shaft** • Clean and lubricate if necessary. • Ensure that pump shaft bearings are properly seated. • Install a bearing clip, if missing. • Remove drive module and ensure that pump shaft moves smoothly. **G. Mechanical interference from the valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. **H. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
4. Event code 274: Pump motion error.	**A. Defective MEA** • Replace MEA.
5. Event code 275: Pump does not home.	**A. Intentional demonstration of faults by operator** • Reset and retry. **B. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that pump latch does not bind with the slide link. **C. Motor or encoder connector loose** • Remove battery pack, main housing and display module. • Reseat motor and encoder connectors. **D. Particles on encoder disc or encoder sensor** • Remove cover from affected encoder. • Using clean, dry compressed air, blow disc and sensors clean. (Table continued next page)

Table 6-12. Drive System Errors (Cont.)

Symptom	Possible Cause and Action
5. Event code 275: Pump does not home (continued).	**E. Mechanical interference from the pump shaft** • Ensure that pump shaft bearings are properly seated. • Clean and lubricate if necessary. • Install a bearing clip, if missing • Remove drive module and ensure that pump shaft moves smoothly. **F. Defective drive module encoder** • Install primed cassette in affected channel. • Attach display module to extender cable. • Attach test keypad and audio/connector PCBA. • Connect replacement test drive module by attaching jumper cables to suspect encoder. • Operate at rate the problem occurred, or 999 ml/h. • If problem does not repeat, replace the suspected drive module. **G. Defective drive module or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace drive module. • Connect motor to a 5V power supply (red wire to positive) and verify that drive runs smoothly. • If motor does not operate, it must be replaced. **H. Mechanical interference from valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components, if necessary. **I. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
6. Event code 277: Pump motion hindered.	**A. Cassette piston sleeve lifted** • Remove the cassette and reseat the piston sleeve. **B. Cassette defective** • If possible, inspect cassette to ensure that piston moves freely. **C. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that pump latch does not bind with the slide link. **D. Motor or encoder connector loose** • Remove battery pack, main housing and display module. • Reseat motor and encoder connectors.

(Table continued next page)

Table 6-12. Drive System Errors (Cont.)

Symptom	Possible Cause and Action
6. Event code 277: Pump motion hindered (continued).	**E. Drive belt slipping** • Inspect drive belt and pulleys to ensure they are free from lubricant. Replace if contaminated. • With display module attached via the extender cable, operate instrument with a fluid-filled cassette. Apply load by pinching off outlet tubing. Inspect for slippage under this load. If the belt slips, clean cam and replace belt. **F. Defective drive module encoder** • Install primed cassette in affected channel • Attach display module to extender cable. • Attach test keypad and audio/connector PCBA. **G. Defective power supply PCBA** • Test with replacement power supply PCBA. • If problem does not repeat, replace suspect PCBA. **H. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. **I. Defective drive module mechanism or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace drive module. • Connect motor to a 5V power supply (red wire to positive) and verify that drive runs smoothly. • If motor does not operate, it must be replaced. **J. Mechanical interference from pump shaft** • Clean and lubricate if necessary. • Ensure that pump shaft bearings are properly seated. • Install a bearing clip, if missing. • Remove drive module and ensure that pump shaft moves smoothly. **K. Mechanical interference from valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. (Table continued next page)

Table 6-12. Drive System Errors (Cont.)

Symptom	Possible Cause and Action
7. Event code 282 or 283: Pump motion hindered.	**A. Cassette piston sleeve lifted** • Remove the cassette and reseat the piston sleeve. **B. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that pump latch does not bind with the slide link. **C. Drive belt slipping** • Inspect drive belt and pulleys to ensure they are free from lubricant. Replace if contaminated. • With display module attached via the extender cable, operate instrument with a fluid-filled cassette. Apply load by pinching off outlet tubing. Inspect for slippage under this load. If the belt slips, clean cam and replace belt. **D. Defective power supply PCBA** • Test with replacement power supply PCBA. • If problem does not repeat, replace suspect PCBA. **E. Defective drive module or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace drive module. • Connect motor to a 5V power supply (red wire to positive) and verify that drive runs smoothly. • If motor does not operate, it must be replaced. **F. Mechanical interference from pump shaft** • Remove drive module and ensure that pump shaft moves smoothly. • Clean and lubricate if necessary. • Install a bearing clip, if missing. • Ensure that pump shaft bearings are properly seated. **G. Mechanical interference from valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. **H. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem. (Table continued next page)

Table 6-12. Drive System Errors (Cont.

Symptom	Possible Cause and Action
8. Event codes 278, 297 & 298: Drive system error.	**A. Defective MEA** • Replace MEA.
9. Pump does not home during power-up and no fault 275.	**A. Dirt in optomodule or slide link sensing area** • Clean optomodule, using procedures described in Chapter 4. **B. Cassette I.D. optics defective, dirty or wet** • Test with replacement cassette. • If problem does not repeat, the cassette optics may have been defective, dirty or wet. • Return defective cassettes to the Technical Service Dept. **C. Optomodule flex dirty** • Remove main housing and expose optomodule flexes. • Clean optomodule flex pads with hard rubber eraser and isopropyl alcohol. **D. Optomodule flex not seated** • Remove main housing and expose the optomodule flex connectors. • Inspect and reseat flex. Ensure that the flexes are centered properly. **E. Defective MEA** • Replace MEA when previous procedures fail to indicate the source of the problem.

Table 6-13. Air-in-Line Sensor Problems

Symptom	Possible Cause and Action
1. False *Check Air Sensor* advisories, cassette in place, or False *Air-in-line* alarms.	**A. Tubing not seated properly or bubbles present** • Refer to Directions For Use for proper priming and installation procedures. **B. Sensor tubing recess dirty** • Clean sensor tubing recess, using procedures described in Chapter 4. **C. Air-in-line sensor connector not seated** • Remove main housing and reseat sensor connectors. **D. Air-in-line sensor defective** • Inspect module for broken glue joints; replace if necessary. • Unplug the suspect sensor module and connect a replacement module. • Place outlet tubing of a primed cassette in the test sensor tubing slot. • Repeat test in which problem occurred. • If problem does not repeat, replace the suspect sensor module. **E. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. *Check Air Sensor* advisory without a cassette installed.	**A. Cassette sensor dirty and pump latch closed** • Open latch. • Clean optomodule sensors, using the procedures described in Chapter 4. **B. Cassette sensor dirty and latch sensor defective** • Clean optomodule sensors, using the procedure described in Chapter 4. • Remove slide link, using procedure described in Chapter 7. • Inspect reflector and replace if damaged. **C. Defective Optomodule** • Measure input and output of the optomodule, as described in Figure 6-1 and 6-2. • If input signals are correct but the output signals are incorrect, replace the optomodule.
3. Fails air bubble functional test.	**A. Test not performed properly** • The pump must infuse a volume of air greater than the air detector threshold for an alarm to occur (see Chapter 3). **B. Air-in-line sensor defective** • Inspect module for broken glue joints; replace if necessary. • Unplug the suspect sensor module and connect a replacement module. • Place outlet tubing of a primed cassette in the test sensor tubing slot. • Repeat test in which problem occurred. • If problem does not repeat, replace the suspect sensor module.
4. Event codes 286, 287, 288, 294 & 295: Air sensor error.	**A. Air-in-line sensor connector not seated** • Remove main housing and reseat the connector. **B. Air-in-line sensor defective** • Inspect module for broken glue joints; replace if necessary. • Unplug the suspect sensor module and connect a replacement module. • Place outlet tubing of a primed cassette in the test sensor tubing slot. • Repeat test in which problem occurred. • If problem does not repeat, replace the suspect sensor module. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-14. Patient-Side Occlusion Detector Problems

Symptom	Possible Cause and Action
1. False alarms, or alarms when pressure is too low.	**A. Defective cassette** • Inspect the cassette to ensure that the pressure sensing dome is flat and flush with the cassette body. **B. Interference between cassette and pressure transducer** • Inspect the pressure transducer area in the chassis to ensure that it is free of foreign debris. Clean with mild detergent solution if needed. **C. Improper calibration** • Recalibrate, ensuring correct pressures are applied (see Chapter 5). **D. Pressure transducer connector loose or defective** • Remove main housing and display module. • Reseat pressure transducer connector. **E. Defective pressure transducer** • Inspect for broken wires. Replace transducer if any wires are broken. • Using the pressure transducer jumper cable, connect the suspect transducer to a channel that operates properly. • Recalibrate the replacement channel; but, apply pressure to the suspect transducer. • If the problem recurs, replace the suspect transducer. **F. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. Patient-side occlusion alarm does not occur at specified pressure.	**A. Improper calibration** • Recalibrate, ensuring the correct pressures are applied (see Chapter 5). **B. Pressure transducer connector loose or defective** • Remove main housing and display module. • Reseat pressure transducer connector. **C. Defective pressure transducer** • Inspect for broken wires. Replace transducer if any wires are broken. • Using the pressure transducer jumper cable, connect the suspect transducer to a channel that operates properly. • Recalibrate the replacement channel; but, apply pressure to the suspect transducer. • If the problem recurs, replace the suspect transducer. **D. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
3. Event code 270 or 280: Pressure sensor error.	**A. Pressure transducer connector loose or defective** • Remove main housing and display module. • Reseat pressure transducer cable. **B. Defective pressure transducer** • Inspect for broken wires. Replace transducer if any wires are broken. • Using pressure transducer jumper cable, connect the suspect transducer to a channel that operates properly. • Recalibrate the replacement channel; but, apply pressure to suspect transducer. • If problem recurs, replace the suspect transducer. **C. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

Table 6-15. Fluid-Side Occlusion Detector Problems

Symptom	Possible Cause and Action
1. False alarms.	**A. Cassette lubrication inadequate** • Exceeding cassette-use specification can result in loss of lubrication. If cassette is new and defective, please contact the Customer Service Department. **B. Improper calibration** • Recalibrate, ensuring correct procedures (see Chapter 5). **C. Mechanical interference from latching mechanism** • Remove the lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. **D. Defective drive module or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close the latch. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If cam does not rotate smoothly, remove the drive belt. • If isolated cam does not rotate, replace drive module. • Connect motor to a 5V power supply (red wire to positive) and verify that drive runs smoothly. • If motor does not operate, then replace. **E. Mechanical interference from pump shaft** • Ensure that pump shaft bearings are properly seated. • Install a bearing clip, if missing. • Remove drive module and ensure that pump shaft moves smoothly. Clean and lubricate if necessary. **F. Mechanical interference from valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.
2. Does not pass functional test.	**A. Defective cassette** • Exceeding cassette-use specification can result in loss of lubrication. If cassette is new and defective, please contact the Customer Service Department. (Table continued next page)

Table 6-15. *Fluid-Side Occlusion Detector Problems (Cont.)*

2. Does not pass functional test (continued).	**B. Defective cassettes during calibration** • Check for smooth operation of the piston. • Note that a piston sleeve must not be used with this cassette. • Last elastomeric valve area in the cassette must be removed. • Replace cassette if defective. **C. Mechanical interference from latching mechanism** • Remove lower housing. • Remove a piston from a cassette. Place cassette piston in pump latch and close the latch. • Verify that pump latch does not bind with the slide link. **D. Defective drive module or motor** • Remove a piston from a cassette. • Put the piston in the pump latch and close. • Verify that the pump latch does not bind with the slide link. • Rotate affected drive cam manually, being careful not to get grease on the belt. • If isolated cam does not rotate, replace drive module. • Connect motor to a 5V power supply (red wire to positive) and verify that drive runs smoothly. • If motor does not operate, then replace. **E. Mechanical interference from pump shaft** • Ensure that pump shaft bearings are properly seated. • Install a bearing clip, if necessary. • Remove drive module and ensure that pump shaft moves smoothly. Clean and lubricate if necessary. **F. Mechanical interference from valve actuators** • Remove drive module. • Verify that valve actuators move smoothly. • Verify that valve actuator springs are seated properly. • Check actuator bearings for smooth operation. • Replace defective components if necessary. **G. Defective MEA** • Replace MEA when the above procedures fail to indicate the source of the problem.

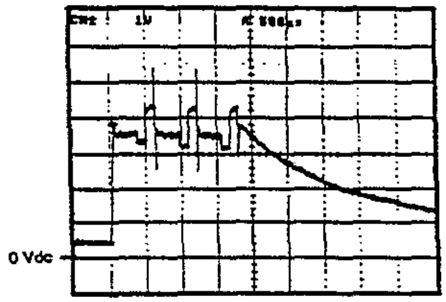
Table 6-16. Instrument Won't Shut Off

- Disconnect the NiCd battery pack to shut the instrument off.
- Plug in a NiCd battery pack that has been charged for at least 1 hour.
- Turn on the instrument by pressing the ON/OFF key and troubleshoot using the observed response.

NOTE: The instrument may have turned on when the battery pack is first connected. This is a normal occurrence, depending on how the circuitry is initialized when battery power is first applied.

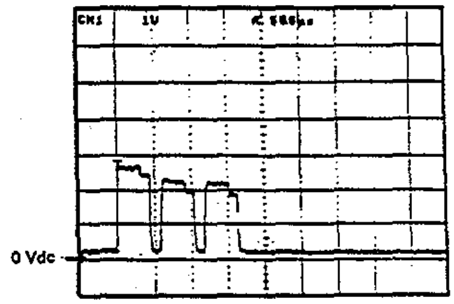
Symptom	Possible Cause and Action
1. Turns on, but will not turn off.	**A. Defective keypad** • If there are no beeps or other instrument responses when the ON/OFF key is pressed, then replace the keypad. **B. Defective power supply PCBA** • If there are three beeps when the ON/OFF key is pressed to turn off the instrument, replace the power supply PCBA. **C. Defective MEA** • Replace MEA when the above procedures fail to eliminate the problem.
2. Instrument watch-dogs and can't be turned off.	**A. Defective keypad** • If there are no beeps or other instrument responses when the ON/OFF key is pressed, replace the keypad. **B. Defective power supply PCBA** • If there are three beeps when the ON/OFF key is pressed to turn off the instrument, replace the power supply PCBA. **C. Defective watchdog circuit on the MEA** • Replace the MEA when the above procedures fail to eliminate the problem.
3. Instrument watch-dogs, but can be turned off.	**Refer to Table 6-3.**
4. Instrument will not turn on at all.	**Refer to Table 6-2.**

Figure 6-1. Cassette I.D. Signals at Optomodule Connector (S5, S6, S7) Located on MEA Mother Board



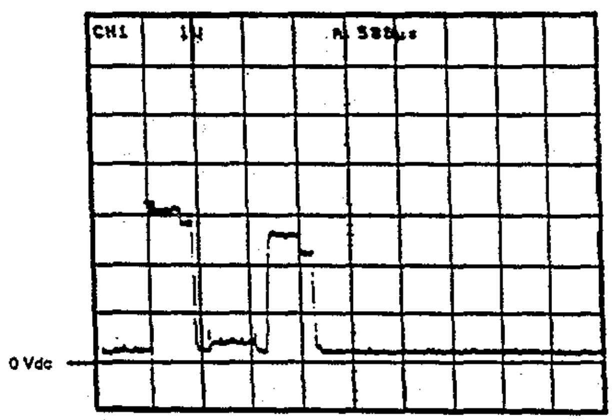
NOTE: High levels should be between 3.0V to 4.5V. Disregard high-frequency spikes.

A. NORMAL INPUT SIGNAL AT PIN 1.



NOTE: There should be three high-level pulses within the range of 0.8V to 4.2V.

B. NORMAL OUTPUT SIGNAL AT PIN 8 WITHOUT A CASSETTE INSTALLED.

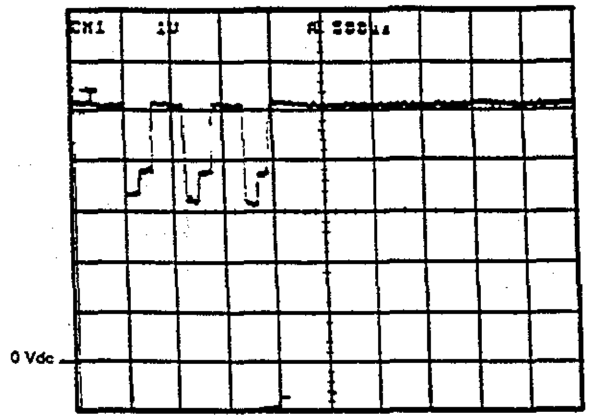


NOTE: There should be two high-level pulses within the range of 0.8V to 4.2V.

C. NORMAL OUTPUT SIGNAL AT PIN 8 WITH A CASSETTE INSTALLED.

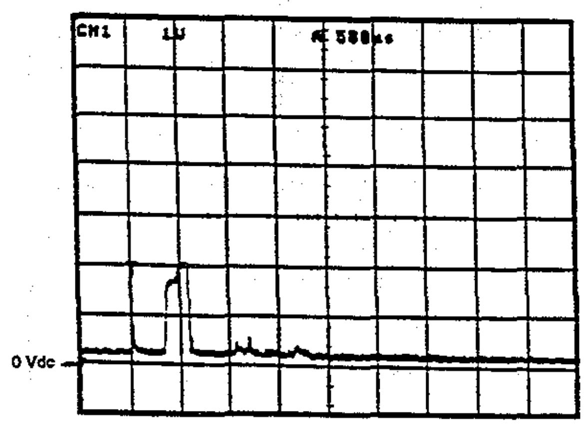
NOTE: Pin 1 is indicated by the square solder tab. Set oscilloscope for a sweep speed of 500 microseconds per division, vertical sensitivity at 1V per division, and DC coupling.

Figure 6-2. Latch Sensor Signals at Optomodule Connector (S5, S6, S7) Located on MEA Mother Board



NOTE: There should be three pulses with the amplitudes dropping from 5.0V to a range between 3.0V and 4.0V.

A. NORMAL INPUT SIGNAL AT PIN 9.



NOTE: There should be one pulse with an amplitude range between 0.8V and 4.2V.

B. NORMAL OUTPUT SIGNAL AT PIN 11 WITH A CASSETTE INSTALLED.

NOTE: Pin 1 is indicated by the square solder tab. Set oscilloscope for a sweep speed of per 500 microseconds per division, vertical sensitivity at 1V per division, and DC coupling.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF FIGURES (continued)

LIST OF TABLES

Chapter 7
Repair

WARNING

It is recommended that only qualified personnel who have received the necessary factory authorized training perform repairs on the MedSystem III instrument.

CAUTION

All repairs should be documented in accordance with your institutional policies. Refer to the Joint Commission on Accreditation of Hospitals Organization (JCAHO) guidelines if there are no pre-existing policies at your institution.

7.0 Introduction

This chapter provides detailed procedures for disassembling, replacing parts, and reassembling the MedSystem III. Following are the five main sections of this chapter.

1. Main Housing Assemblies
2. Universal Pole Clamp
3. Mechanical Subsystems
4. Sensors
5. Electronics

Each section lists the major parts and modules in a sequential order for proper disassembly. Before attempting any repairs, it is necessary that you have a good understanding of the principles of operation (Chapter 2), the functional check procedures (Chapter 3), and the calibration procedures (Chapter 5).

For ease in handling during repair, the instrument may be clamped to a table edge with the universal pole clamp. It can then be rotated and tilted in any orientation for easy access to most parts.

In reference to orientation (up, down, top, bottom, right, left), the user should have the instrument in an upright position and should be facing the front panel (Figure 7-1).

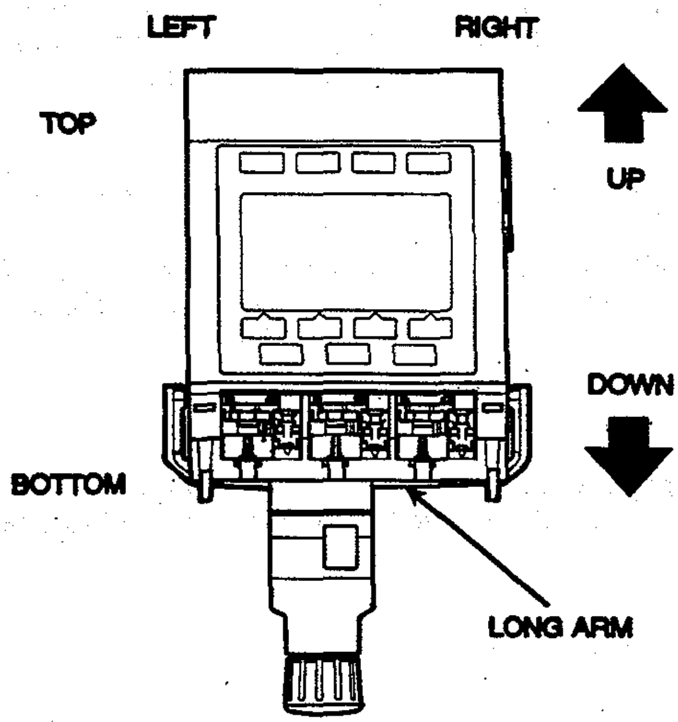
a. Handling Procedures

   Always use the following procedures when handling electronic assemblies or removing the battery pack.

CAUTION

The electronic components used in the MedSystem III instrument can be damaged by electrostatic discharges (ESD).

Figure 7-1. Instrument Orientation during Repair



1. Store PCBAs and transducers in their conductive packaging until ready for use.
2. Wear a 0.5 to 1.5 megohm wrist strap for grounding.
3. Ensure that the workstations have grounded conductive mats or surfaces.
4. All conductive surfaces and equipment must be connected to earth ground.
5. When handling electronic or sensor assemblies, wear clothes that do not generate static.
6. All PCBAs must be handled by the edges.
7. Ideally, room humidity should be kept between 45% and 60%, because static electricity increases exponentially as humidity decreases.
8. For further details, refer to DoD Handbook 263 and DoD Standard 1686.

b. Procedures Following Repair

WARNING

If indicated, the following procedures must be performed to ensure instrument operates properly before it is used on a patient.

1. Calibration
   Calibration of sensor systems is required if memory contents are corrupted during repair, or if specific components are replaced. Corruption of memory content is detected by the software during operation (refer to Troubleshooting, Chapter 6, for event codes). Always recalibrate if indicated. Refer to Chapter 5 for calibration instructions.
2. Run-in
   Whenever a repair procedure necessitates removing the main housing, the instrument should be operated in the general purpose mode for a period of time before returning to clinical service.

   Fluid-filled cassettes must be installed during the run-in period. Set up a recirculating system, using a bag of saline.

   If the battery functional tests are not needed, then use the following procedures to run-in the instrument.

   (a) Operate the instrument for 4 hours, using a rate of 275 ml/h on all three channels.

   (b) Operate the instrument for a minimum of 8 hours (i.e., overnight) with all three channels operating at 999 ml/h. This stresses the power supply and pumping mechanisms, and produces a large number of revolutions for self-testing the encoders and air-in-line sensors.

   NOTE: *The order is not important (i.e., 275 ml/h does not need to be first).*

   If the battery functional tests are required, use the following procedures.

   (a) Completely discharge the battery while operating the instrument without the adapter plugged in and with all three channels set at 275 ml/h to test the 5V circuitry. Continue operating past the *Battery Depleted* alarm until the instrument shuts off.

   (b) Charge the instrument for 14 hours while running all three channels at 999 ml/h to test the 13V circuitry.

   (c) Perform the battery operating time functional tests while operating all three channels of the instrument at 125 ml/h (Chapter 3, Section 3.8).

   (d) Recharge the instrument for 14 hours. Make sure that the instrument is turned off.
3. Functional checks
   Checking instrument performance is necessary after repair. Whenever the main housing is removed, perform a complete functional check with the exception of the battery operating time (Chapter 3). It is recommended that, as a minimum, these checks be performed after the run-in. An optional check of function before run-in is desirable (but not necessary) to quickly find any

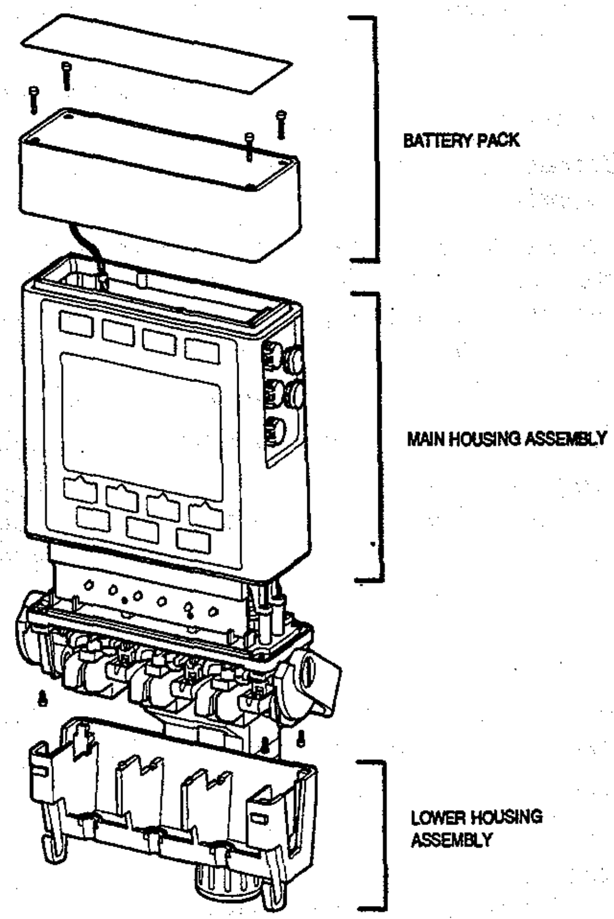
problems. Battery operating time must be checked if the battery, the power supply PCBA, or the MEA are replaced. This operating time can be combined with the run-in procedure (refer to paragraph 2 above).

4. Restoration of Configured Parameters and the Battery History Log
Memory contents can be corrupted during repair. Instrument settings, such as air-in-line alarm thresholds, may have been customized using Field Maintenance Software (FMS). Settings should always be verified for correctness after repair. The serial number and special message may also need reprogramming. For reprogramming instructions refer to the FMS DFU. The Battery History Log data may have been corrupted also, which necessitates clearing and resetting installation dates.

7.1 Housing Assemblies

An exploded view of the housing assemblies is shown in Figure 7-2.

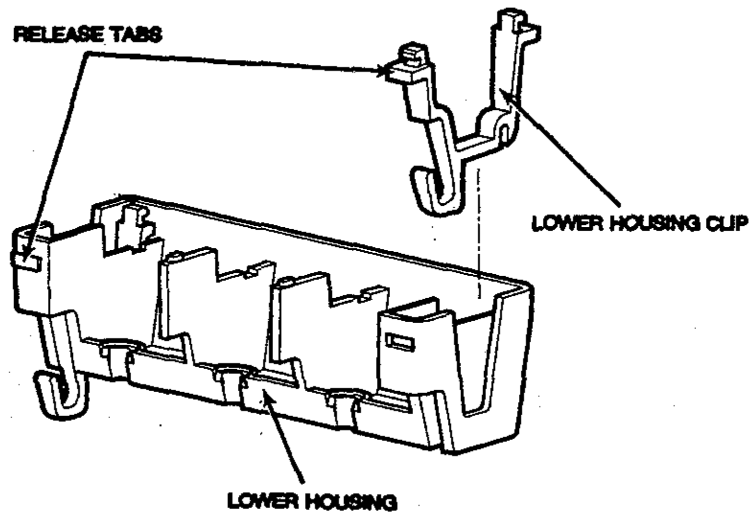
Figure 7-2. Exploded View of Housing Assemblies



7.1.1 Lower Housing Assembly

Figure 7-3 depicts an exploded view of the lower housing and lower housing clips. Use the following procedures when repairing the lower housing.

Figure 7-3. Exploded View of Lower Housing Assembly



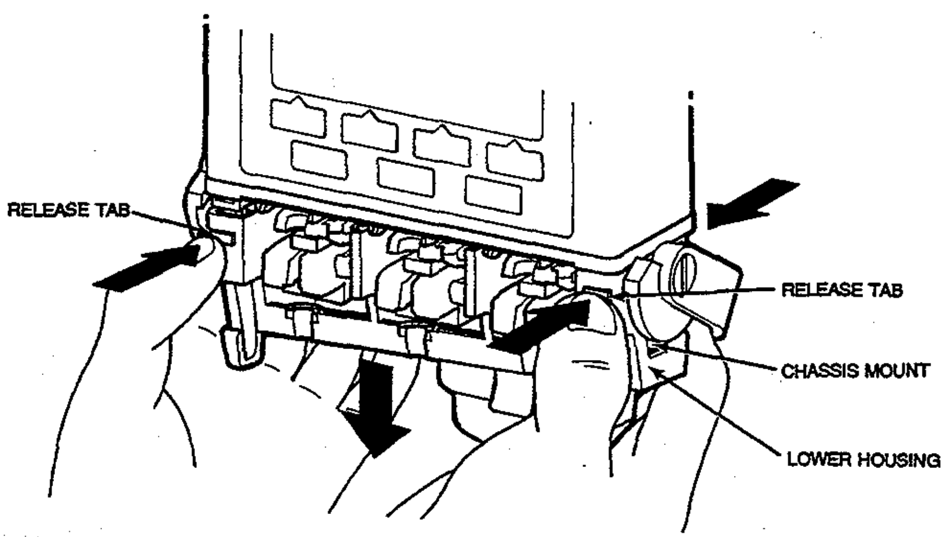
Disassembly

Tool required: Small flat blade screwdriver

a. Remove lower housing assembly.

1. Locate the four black release tabs (Figure 7-4) in the upper corner of the lower housing.

Figure 7-4. Lower Housing Release Tabs



2. With the instrument upright and firmly mounted using the pole clamp, simultaneously press the front and back tabs on each side with your thumb and fingertips.
3. While the tabs are depressed, pull the lower housing straight down and away from the instrument.

b. Inspect for the following.

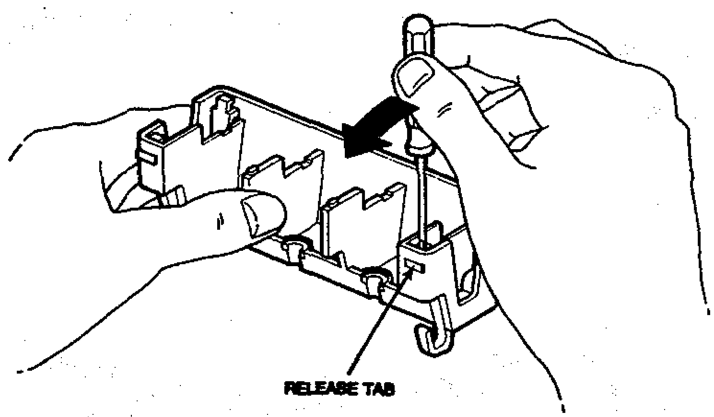
1. Cracked or chipped housing.
2. Broken or bent lower housing clips.
3. Broken chassis mounts.
4. Cleanliness. If necessary, clean using a mild detergent or disinfectant (Chapter 4, Section 4.1).

Reassembly

a. Replace the lower housing clips.

1. Locate the two clips on the front of the lower housing toward the sides.
2. Using a small flat blade screwdriver, pry the black release tabs until they clear the housing slot (Figure 7-5).
3. Push up on the hook to bring the tab above the slot.
4. Repeat the procedure for the back of the lower housing clips.
5. Pull the housing clips from the housing.
6. Install the lower housing by snapping the clips back into position.

Figure 7-5. Lower Housing Clip Replacement



b. Reattach the lower housing assembly to the chassis.

1. Arrange the lower housing on the bottom of the case such that the three cutouts are facing forward.
2. Gently snap the housing up and into place. It is not necessary to press the black buttons to install the lower housing.
3. Pull down slightly to ensure that all four corners are locked in place. If a corner will not lock, remove the lower housing and inspect the lower housing clips and the chassis mounts. If necessary, replace either the clips or the mounts, or both.

7.1.2 Battery Pack

The battery pack is shown in the exploded assembly diagram (Figure 7-6). Use the following procedures to replace the battery pack.

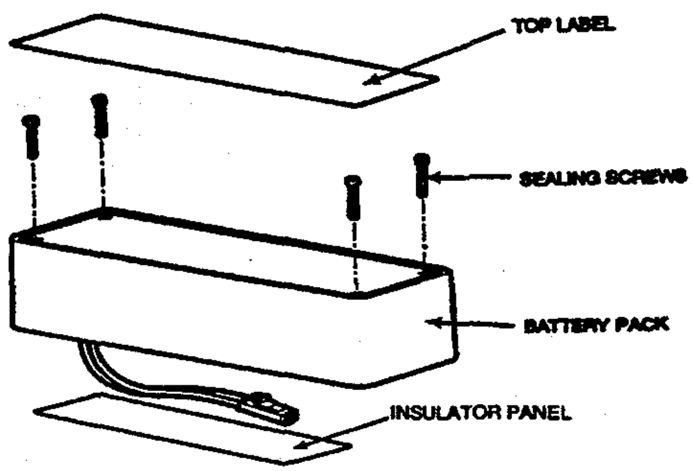
Disassembly

Tool required: #1 Phillips screwdriver

a. Remove the top label (Figure 7-6).

NOTE: *Warming the top label with a heat gun or hair dryer facilitates label removal and minimizes residual adhesive.*

Figure 7-6. Exploded View of Battery Pack



1. Peel up one corner of the label. If a metal tool is used to lift a corner, use care to prevent scratches on the main housing.
2. Pull the label from the surface.
3. Remove residual label adhesive from the top of the battery pack case, using a gentle rubbing motion or oil-free label adhesive remover.
4. Make sure that the surface is clean and free of any contamination.

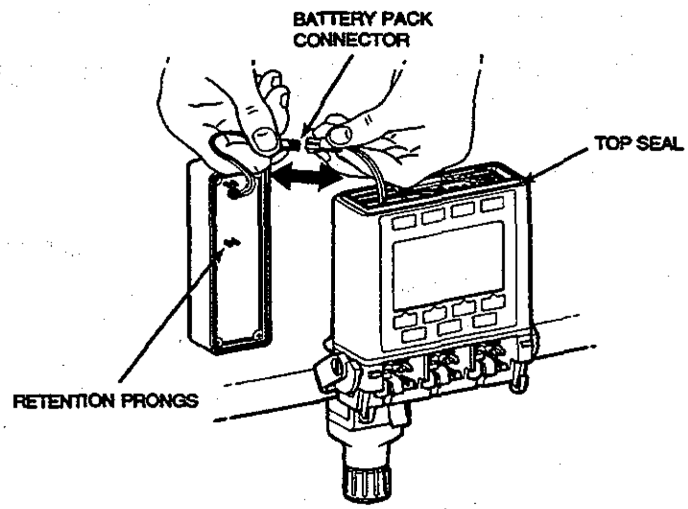
b. Remove the battery pack.

1. Using a #1 Phillips screwdriver, remove the four sealing screws which secure the battery pack (Figure 7-6).
2. Lift the battery pack slowly from the main housing assembly and set it aside. Be careful not to stress the cable.
3. Unplug the battery pack connector (Figure 7-7).

c. Inspect for the following.

1. Cracks and chips.
2. Broken wire or connector.
3. Damage to the top seal in main housing assembly.
4. Broken EPROM retention prongs.

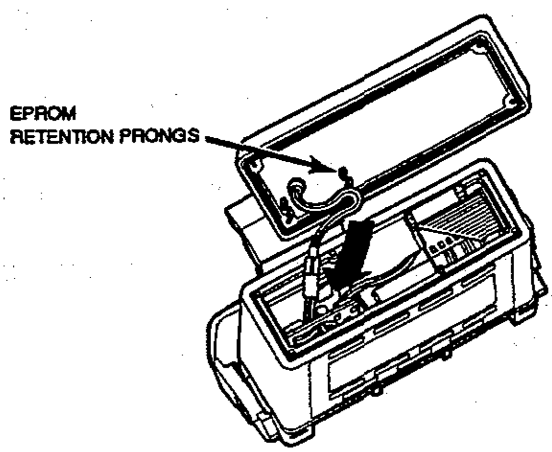
Figure 7-7. ***Battery Pack Removal***



Reassembly

a. Reassemble and reinstall the battery pack. NOTE: If battery was replaced, install insulator panel in center of bottom of battery pack assembly.
   1. Ensure that the top seal is properly seated in the groove of the main housing.
   2. Reattach the battery connector.
   3. Gently place the wires and connector into the space in front of the EPROM PCBA (Figure 7-8).

Figure 7-8. ***Battery Pack Reassembly and Reinstallation***



   4. Fit the battery pack onto the main housing assembly with the printing on the top readable from the front.
   5. Capture the EPROM PCBA with the two retention prongs located on the bottom of the battery pack.
   6. Using the #1 Phillips screwdriver, install four **new** sealing screws and tighten until snug. DO NOT OVERTIGHTEN. The screws should not be reused because they contain a seal that can flatten and, hence, may not seal properly.

b. Affix a new top label.

c. Cycle the batteries.
The battery alarms may not be accurate the first time that the NiCad cells are used. Before performing a functional test of battery operating time, completely discharge the batteries by running the instrument at 999 ml/h (all three channels) until shutoff occurs after the *Battery Depleted* alarm. Then charge the batteries for at least 14 hours.

d. Clear the Battery History Log (refer to the FMS DFU).

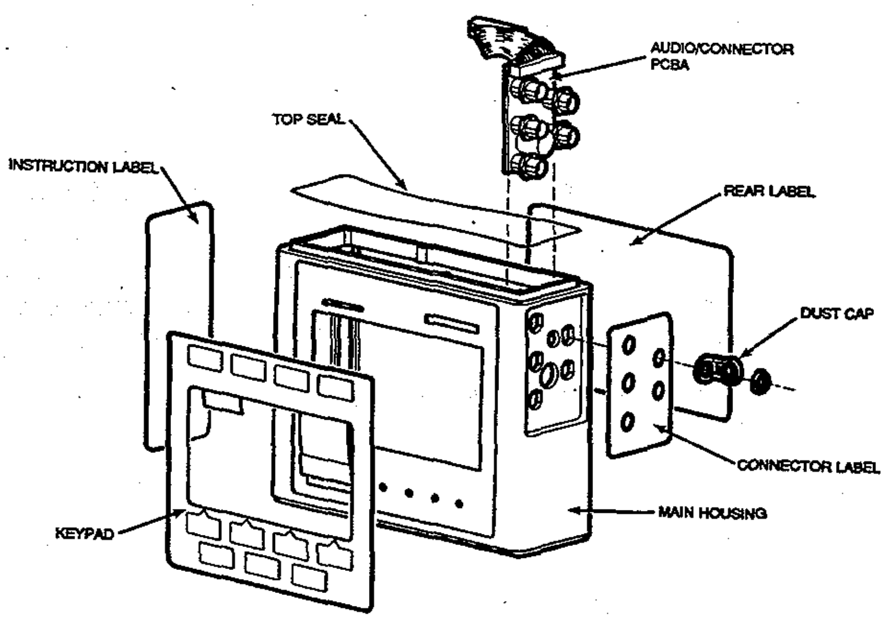
1. Verify that the instrument powers up properly (Chapter 3, Section 3.2).
2. If the battery was replaced, use FMS to clear the Battery History Log. Enter the installation date.
3. For a new battery, verify the proper charging, operating time, and alarms (Chapter 3, Section 3.8).

e. Perform the functional checks (Chapter 3).

7.1.3 Main Housing Assembly

Figure 7-9 is an exploded view of the main housing assembly and related parts. To replace the main housing assembly, use the following steps.

Figure 7-9. Exploded View of Main Housing Assembly



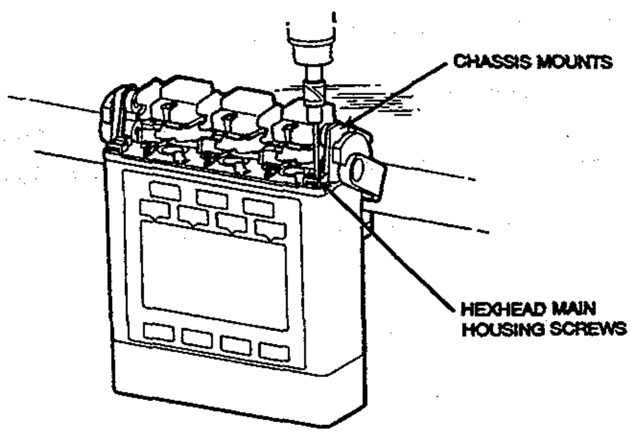
Disassembly

Tools required:
- #1 Phillips screwdriver
- 3/32-inch hex driver
- 5-in. lbf torque driver
- A nonconductive tool

a. First, remove the following.
   1. Battery pack (Section 7.1.2).
   2. Lower housing assembly (Section 7.1.1).

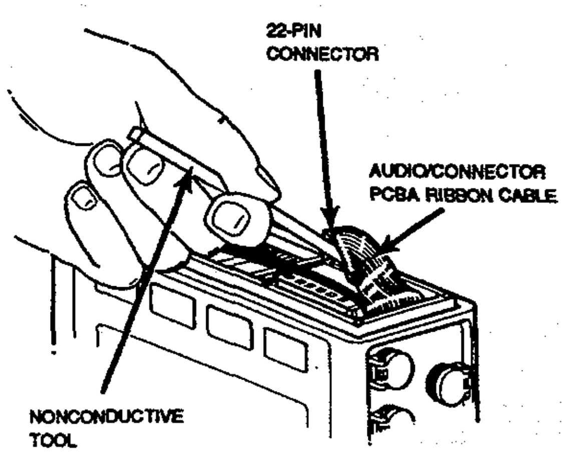
b. Remove the main housing assembly from chassis.
   1. Attach the pole clamp firmly to a table.
   2. Invert the instrument.
   3. Locate the four hex-head main housing screws located in each corner of the chassis (Figure 7-10).

Figure 7-10. Hex-head Screws of Main Housing Assembly Removal



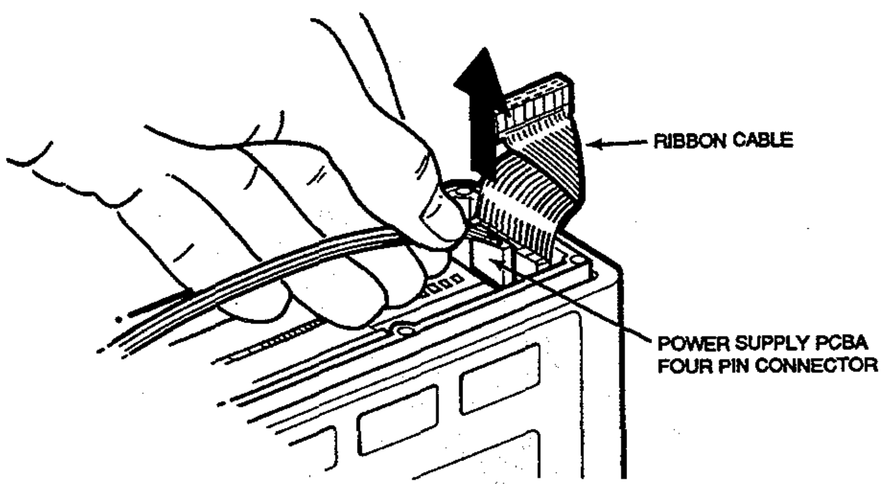
   4. Remove the screws through the square holes in the chassis mounts, using the 3/32-inch hex driver.
   5. Return the instrument to an upright position. On the right side of the instrument is the ribbon cable (Figure 7-11) from the audio/connector PCBA. Using a nonconductive tool, gently pry up the 22-pin connector on the ribbon cable.

Figure 7-11. Audio/Connector PCBA Ribbon Cable



6. A four-pin connector from the power supply PCBA is located under the ribbon cable (Figure 7-12). Unplug this connector.

Figure 7-12. Power Supply PCBA Four-Pin Connector

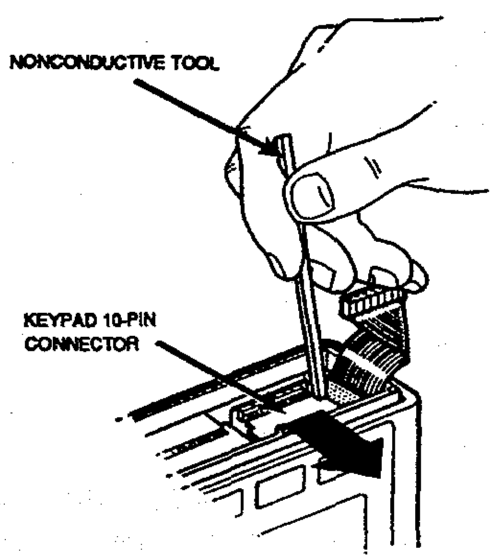


7. To the left of the power supply PCBA connector (under the ribbon cable) is a 10-pin connector from the keypad. Remove this 10-pin connector by pressing forward alternately on one side and then the other, using a nonconductive tool (Figure 7-13).

CAUTION

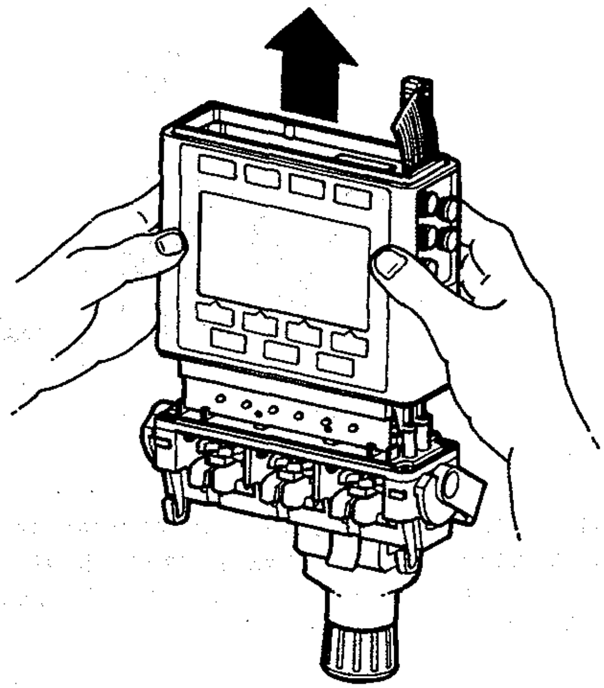
Be careful not to bend the connector cable excessively while removing the case from the instrument.

Figure 7-13. Keypad Ten-Pin Connector



8. Carefully slide the main housing assembly straight up and off the instrument (Figure 7-14).

Figure 7-14. Main Housing Assembly

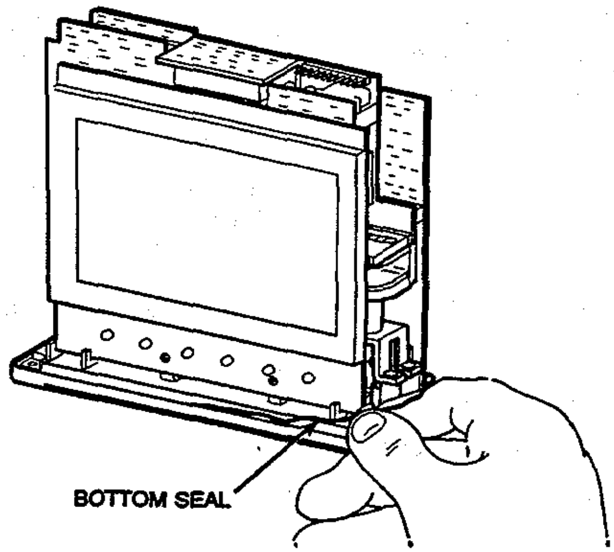


c. Inspect for the following.
   1. The serial number on the underside of the chassis is consistent with the serial number on the rear label.
   2. Cracked or chipped housing.
   3. Broken or loose screw inserts.
   4. Delaminated keypad.
   5. Cracked or damaged keys.
   6. Damaged bottom seal.
   7. Loose connectors.
   8. Broken wires.
   9. Broken or missing dust caps.
   10. Missing or defaced labels.

Reassembly

a. Reassemble the main housing assembly to the chassis.
   1. Ensure that the bottom seal is properly seated on the chassis (Figure 7-15).
   2. Carefully slide the main housing assembly over the internal components until it is seated against the chassis.

Figure 7-15. Bottom Seal Replacement

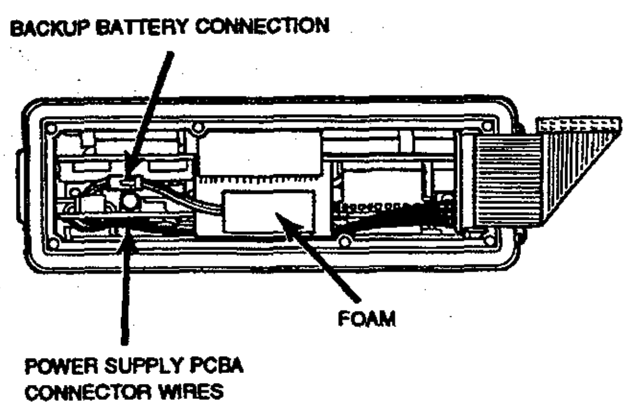


3. Attach the connectors in the following order: (1) keypad [10-pin], (2) power supply PCBA [4-pin], (3) audio/connector PCBA [22-pin], and (4) battery pack. Place the wires for the power supply PCBA connector as shown in Figure 7-16.

CAUTION

Be careful not to bend the connector cable excessively while attaching the case to the instrument.

Figure 7-16. Power Supply PCBA Connector Wire Replacement



4. Depress the ON key and verify that the instrument powers up.
5. Rotate the instrument to orient the bottom of the chassis in an up position.
6. Replace the main housing screws, tightening to a torque of 5 in. lbf.
7. Reassemble the battery to the main housing.

b. Verify the memory contents and restore if necessary.
   1. Turn on the instrument. If calibration parameters have been corrupted, self-tests will produce a fault alarm. If this happens, recalibrate using the procedures referenced in Chapter 5.
   2. Verify that the customized settings are correct (refer to FMS).
   3. Verify that the Battery History Log information has not been corrupted. If corrupted, use FMS and enter the information again.

c. Test
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except battery operating time.

7.1.4 Dust Cap Replacement

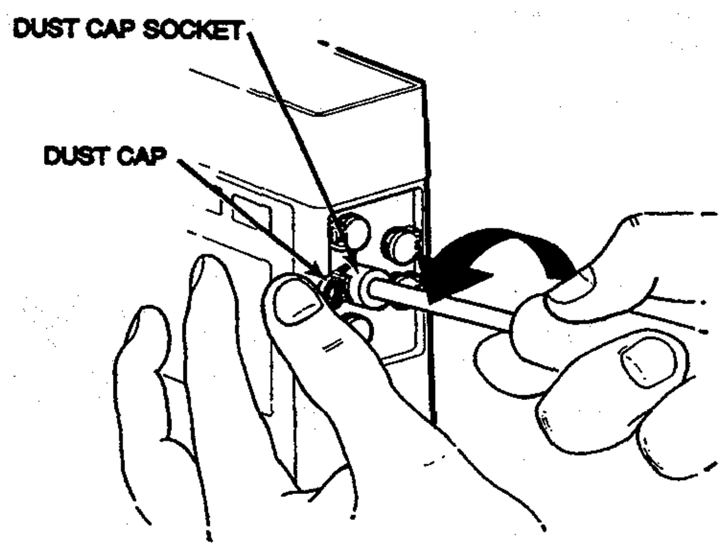
Tool required: Dust cap socket

Disassembly

a. Remove dust caps.
   1. Lift the dust cap (Figure 7-17). Using the dust cap socket, remove the retaining nut by turning counterclockwise.

b. Remove the dust cap, noting its orientation.

Figure 7-17. Dust Cap Removal



Reassembly

a. Replace the following.
   1. Using the retaining nut, secure the dust cap in the proper orientation.
   2. Use care to prevent cross-threading or overtightening of the nut. Very little force is required to hold the cap in place and prevent it from spinning.

b. Perform the following functional tests (Chapter 3).
  1. Electrical safety.
  2. Power-up and AC indication.
  3. Communications.

7.1.5 Rear Label and Instruction Label Removal and Replacement

NOTE: *Some instruments have rear labels with the UL approval symbol on the label. Others have the UL symbol affixed on the bottom of the chassis.*

a. Remove the rear label.

   NOTE: *Warming the rear label with a heat gun or hair dryer facilitates label removal and minimizes residual adhesive.*
  1. Peel up one corner of the label. If a metal tool is used to lift a corner, use care to prevent scratching the main housing.
  2. Pull the label from the surface.
  3. Remove any residual label adhesive from the main housing by using a gentle rubbing motion or label adhesive remover.
  4. Make sure that the surface is clean and free of any contamination.

Reassembly

a. Replace the rear label.
  1. Attach the rear label to the main housing.

b. Replace the instruction label.
  1. If the instruction label needs to be replaced, attach the new label in the same location as the old one.

7.1.6 Audio/Connector PCBA and Label Replacement

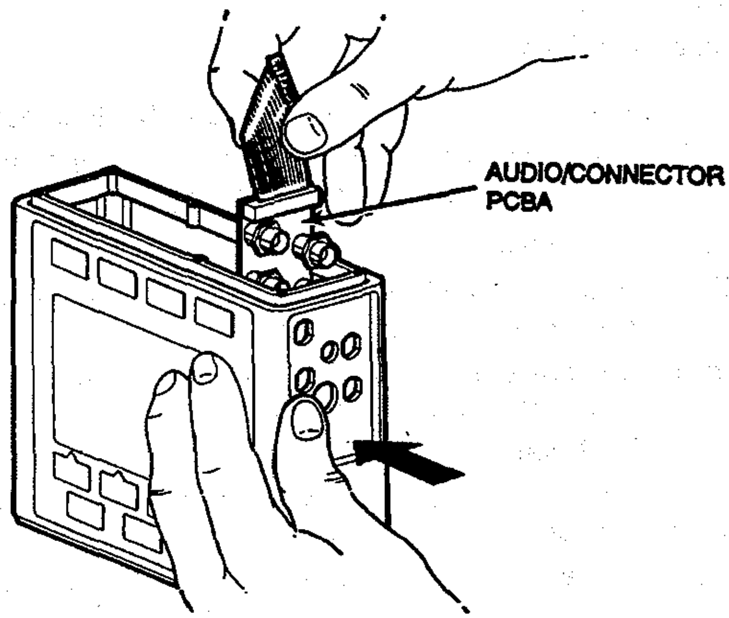
Tools required:
- #1 Phillips screwdriver
- 3/32-inch hex driver
- Dust cap socket
- Silicone sealant (Dow Corning 739 or equivalent)

Disassembly

a. First, remove the following.
  1. Lower housing assembly (Section 7.1.1).
  2. Battery pack (Section 7.1.2).
  3. Main housing assembly (Section 7.1.3).
  4. Dust caps (Section 7.1.4).

b. Remove the PCBA.
  1. Gently press the connectors through the holes in the main housing.
  2. Remove the PCBA (Figure 7-18).

Figure 7-18. Audio/Connector PCBA Removal

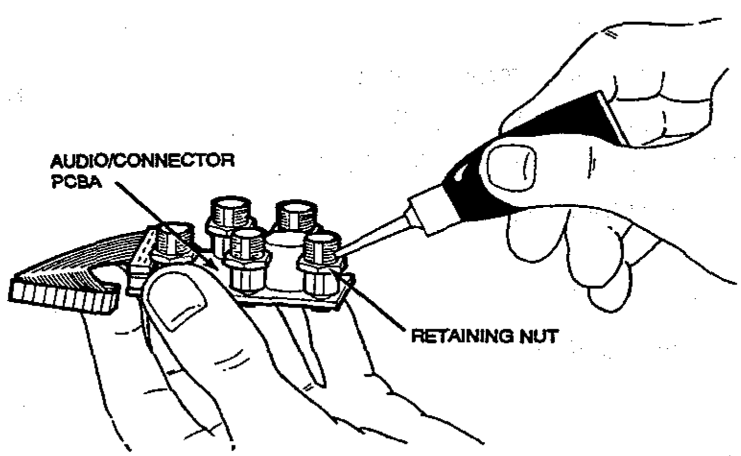


Reassembly

NOTE: *The INSIDE retaining nuts on each connector are set at the factory to a precise position for proper dust cap operation. DO NOT change the position of these nuts.*

1. Remove and clean any old sealant from the connectors.
2. Seal the gap between the housing and the connectors (Figure 7-19) by applying a small amount of silicone sealant around each connector before the audio/connector PCBA is installed. Do not overapply sealant.
3. Replace the audio/connector PCBA. Secure with retaining nuts and dust caps, as described in Section 7.1.4.

Figure 7-19. Sealant Application



4. Replace the EXTERNAL POWER/COMM label if necessary.

a. Reassemble the instrument in the following order.
   1. Main housing assembly (Section 7.1.3).
   2. Battery pack (Section 7.1.2).
   3. Lower housing assembly (Section 7.1.1).

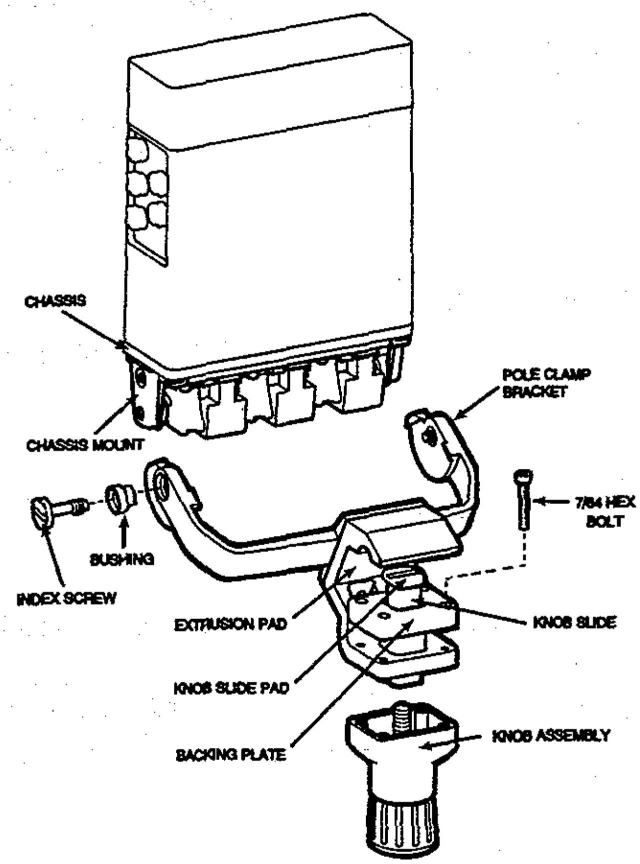
b. Verify the memory contents and restore if needed.
   1. Turn on the instrument. If calibration parameters have been corrupted, self-tests will produce a fault alarm. If this happens, recalibrate using the procedures referenced in Chapter 5.
   2. Verify that the customized settings are correct (refer to FMS).
   3. Verify that the Battery History Log information has not been corrupted. If corrupted, use FMS and enter the information again.

c. Test.
   1. Perform run-in (Section 7.1) and all the functional tests (Chapter 3) except the battery operating time.

7.2 Universal Pole Clamp

Figure 7-20 shows an exploded view of the universal pole clamp and related parts.

Figure 7-20. Exploded View of Universal Pole Clamp and Related Parts



7.2.1 Pole Clamp Assembly Replacement

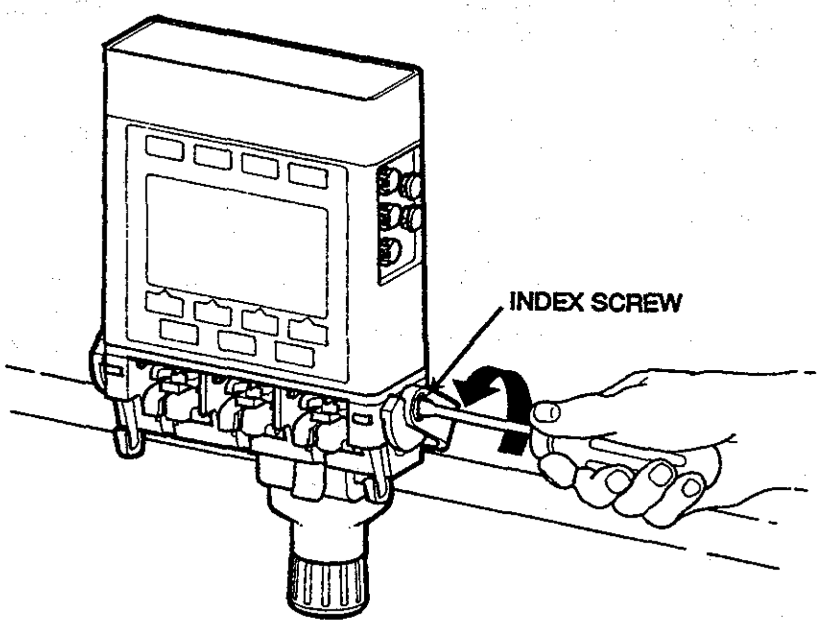
Tool required: 5/16-inch flat blade screwdriver

Disassembly

a. Remove the pole clamp from the instrument.

   1. Loosen the two index screws located on either side of the bracket (Figure 7-21), using a 5/16-inch flat blade screwdriver or a coin. It is not necessary to completely remove the screws to separate the pole clamp from its mounts.

Figure 7-21. Location of Pole Clamp Bracket Index Screws



b. Inspect for the following.

   1. Bent bracket on either side that scrapes the housing.
   2. Broken or loose knob assembly.
   3. Clutch out of adjustment or broken.
   4. Missing or damaged pads.

Reassembly

a. Reattach the pole clamp to the instrument.

   1. Position the bracket so that the two index screws are aligned over the threaded holes in the chassis mount.
   2. Tighten the screws until they are snug (DO NOT overtighten).
   3. Replace the screws if they loosen when the instrument is tilted several times front to back.

b. Check to ensure the following.

   1. The pole clamp pivots properly on the chassis mounts and the knob turns freely.

2. The clutch is properly adjusted. A solid "click" sound should be heard when the knob is tightened completely (refer to Section 7.3.2 if the clutch needs adjustment).

7.2.2 Pole Clamp Bracket, Knob Assembly, or Slide Replacement

Tools required:

- 5/16-inch flat blade screwdriver
- 7/64-inch ball-end hex wrench
- 5/64-inch hex wrench

Disassembly

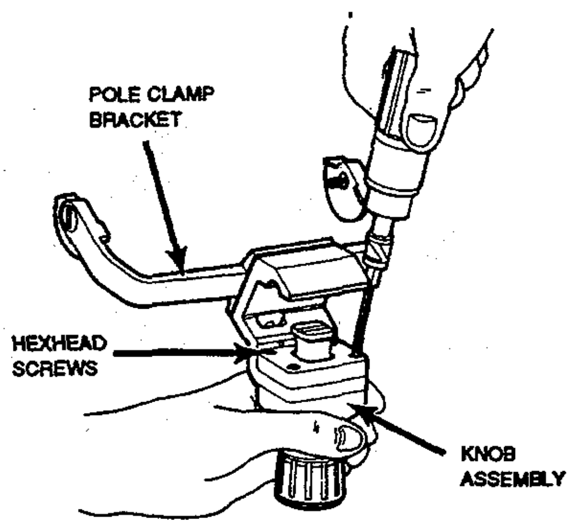
a. First, remove the following.

   1. Pole clamp assembly from the instrument (Section 7.3.1).

b. Disassemble the knob assembly.

   1. Separate the knob assembly from the pole clamp bracket by removing the four hexhead screws, using a 7/64-inch ball-end hex wrench (Figure 7-22).

Figure 7-22. Knob Assembly



   2. After removing the screws, turn the knob clockwise while pulling back on the knob assembly (Figure 7-23).
   3. Continue this procedure until the knob assembly slide is completely unscrewed from the threaded shaft.
   4. Remove the knob assembly slide by pressing the backing plate out of the square hole in the mount (Figure 7-24).

Reassembly

Reverse the order of disassembly.

When mounting the pole clamp, the long arm of the pole clamp bracket must be to the right, as shown in Figure 7-1.

Figure 7-23. Knob Assembly Slide

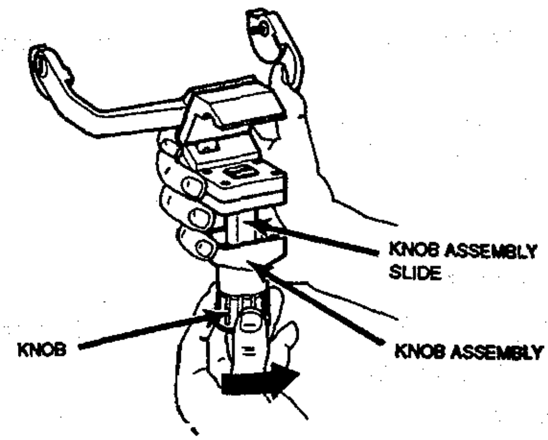
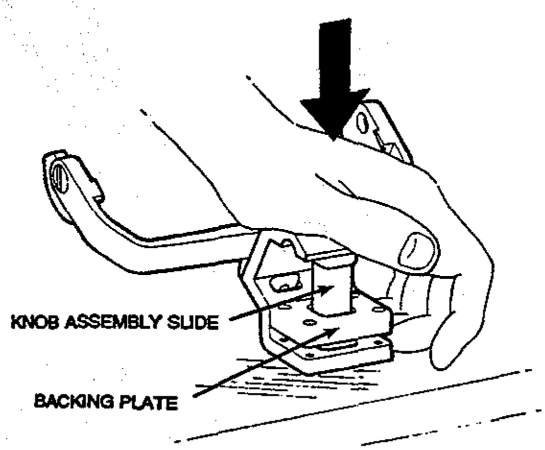


Figure 7-24. Knob Assembly Clutch Adjustment Screw



a. Adjust the clutch.

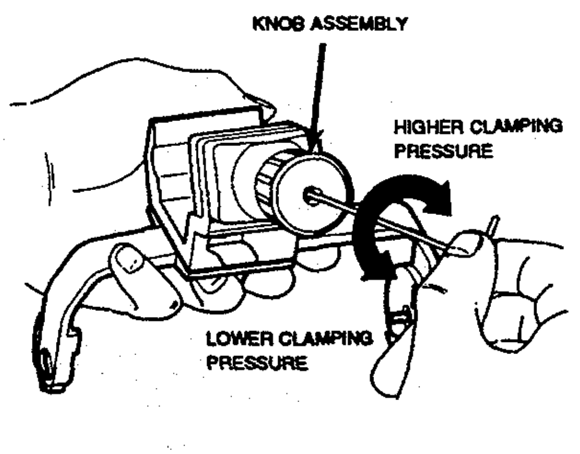
   The pole clamp contains a slip clutch that allows consistent tightening to the proper pressure.

   1. Using a 5/64-inch hex wrench, turn the clutch adjustment screw in the back of the knob assembly clockwise until it stops (Figure 7-25).
   2. Back the screw out counter-clockwise for one-half turn.
   3. The clamping pressure may be adjusted tighter by turning the screw clockwise, or looser by turning counterclockwise.

b. Inspect to ensure the following.

   1. The pole clamp pivots properly on the mounts, and the knob turns freely.
   2. The clutch is adjusted properly. A solid "click" sound is produced when the knob is completely tightened.

Figure 7-25. Knob Assembly Slide Removal



7.2.3 Knob Assembly Slide Cap Replacement

Tools required:

- Isopropyl alcohol
- Lint-free swabs
- Loctite® 401 Superbonder

Disassembly

a. Remove the following.

   1. Damaged slide cap from the knob assembly slide.

b. Clean the following.

   1. Any remaining dried adhesive from the top of the knob assembly slide.
   2. The top of the knob assembly slide, using a clean swab and isopropyl alcohol.

Reassembly

a. Before beginning the reassembly, perform the following steps.

   1. Clean the inside of the slide cap, using a clean swab moistened with isopropyl alcohol.
   2. Apply a drop of Loctite 401 inside each corner.

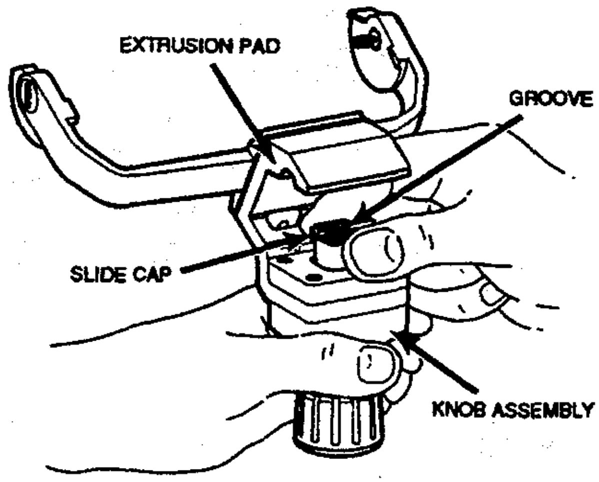
b. After the above steps have been completed, perform the following.

   1. Install the slide cap on the top of the knob assembly slide, ensuring that the groove in the slide cap is parallel to the groove in the extrusion pad (Figure 7-26).

CAUTION

Further disassembly of the pole clamp is not recommended. Special equipment is necessary for reassembly beyond this point.

Figure 7-26. Knob Assembly Slide Cap Replacement



7.2.4 Pole Clamp Bracket Bushing Replacement

Tool required: 5/64-inch flat blade screwdriver

Disassembly

1. First, remove the pole clamp assembly from the instrument (Section 7.2.1).
2. Remove the index screw.
3. Using a blunt instrument, push out the bushing from the inside of the pole clamp bracket (refer to Figure 7-21 for the bushing location).

Reassembly

1. Using a blunt instrument, press in the bushing until it snaps in place.
2. Replace the index screw.
3. Reattach the pole clamp to the instrument (Section 7.2.1).

7.3 Mechanical Subsystems

The mechanical subsystems are depicted in detail in Figure 7-27.

NOTE: *Two different types of chassis were produced. Early versions were machined from aluminum, and the later versions are die cast. The machined aluminum versions are silver colored and can also be identified by the white plastic pump shaft sleeve bearings (Figure 7-28). Die cast chassis use a shorter air-in-line sensor module seal.*

7.3.1 Pump Latch Assembly and Pump Shaft Seal

Tools required:

- #1 Phillips screwdriver
- 3/32-inch hex driver
- 5/16-inch flat blade screwdriver
- Chassis holding stand
- 0.05-inch hex driver

Figure 7-27. Exploded View of Mechanical Assembly

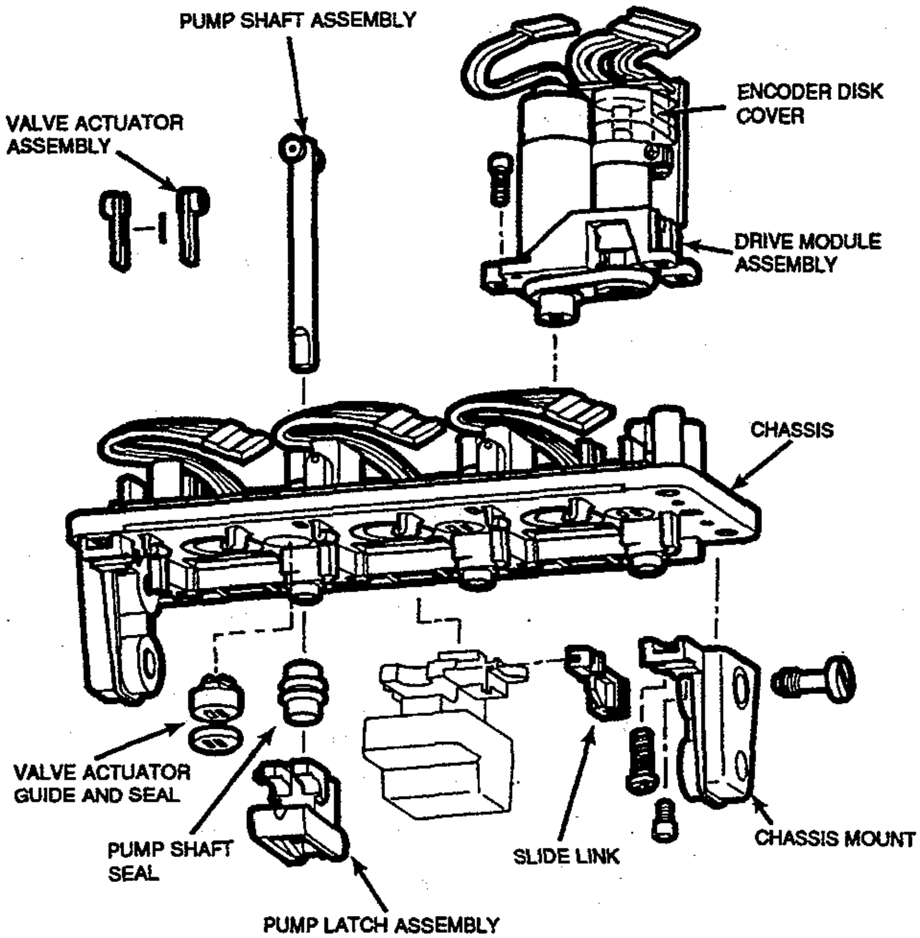
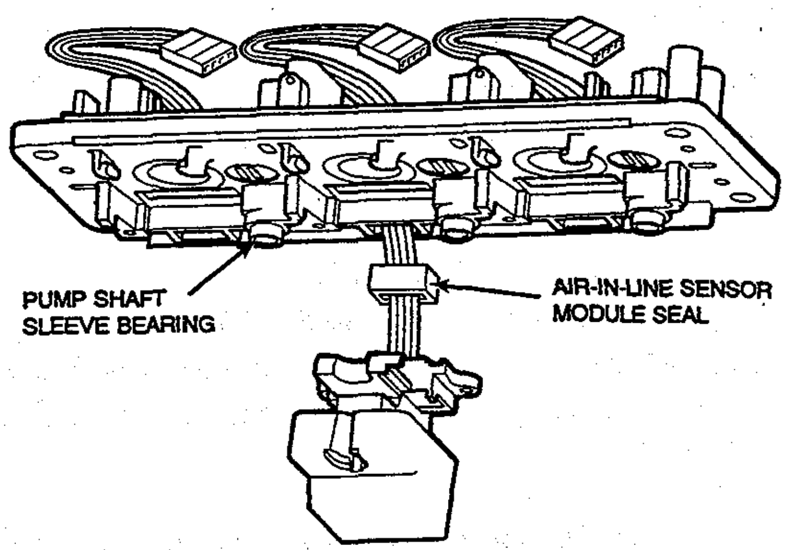


Figure 7-28. Machined Aluminum Chassis (Model 2860 only)

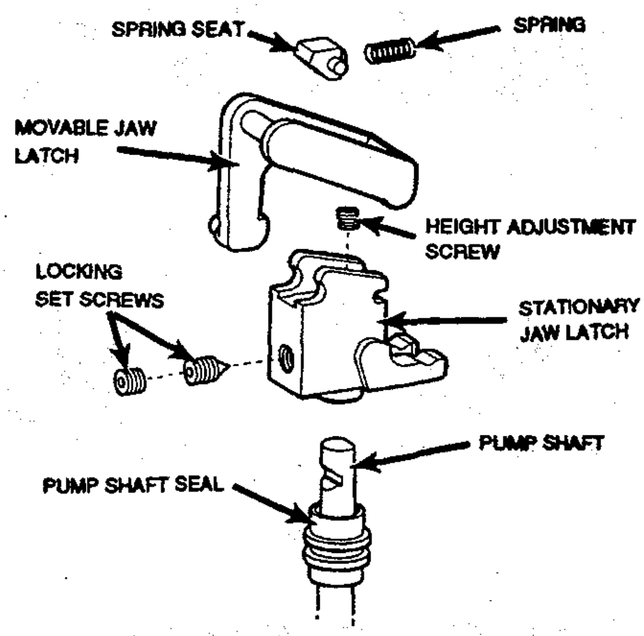


Tools required (continued):

- 0.05-inch Allen key
- 5-in. lbf torque driver (BLUE)
- 3-in. lbf torque driver (RED)
- 5/64-inch ball-end hex driver or T-6 Torx driver
- Loctite® Assure 425 surface curing threadlocker
- Gauge block kit

NOTE: *It is not necessary to lubricate any moving parts of the pump latch assembly (Figure 7-29).*

Figure 7-29. Exploded View of Pump Latch



Disassembly

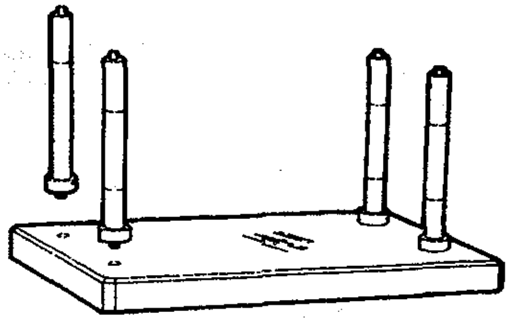
a. First, remove the following.

1. Lower housing assembly (Section 7.1.1).
2. Battery pack (Section 7.1.2).
3. Main housing assembly (Section 7.1.3).
4. Display module (Section 7.5.2).
5. Pole clamp assembly (Section 7.2.1).
6. Ground wire from the chassis (Section 7.5.5).
7. Backup battery from the locking two-pin connector (Section 7.5.3).
8. All motor, encoder, and pressure transducer connections from the MEA (Section 7.4.2).

b. Assemble the chassis holding stand.

1. Screw each of the four chassis-holding stand legs to the chassis-holding stand base (Figure 7-30).

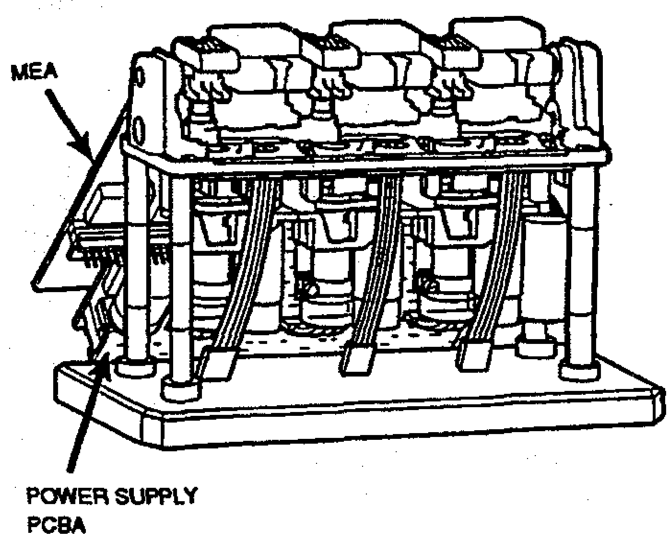
Figure 7-30. Assembly of Chassis Holding Stand



c. MEA Removal

1. Carefully lift the MEA, which has the power supply PCBA attached to it, from the chassis guides. Place the chassis on the chassis holding stand with the drive modules facing down. Position the MEA, which has the power supply PCBA attached, away from the chassis stand so that it allows for correct placement of the chassis (see Figure 7-31).

Figure 7-31. Attachment of Chassis to Holding Stand



d. Loosen the air-in-line sensor module.

1. Remove the two air-in-line sensor mounting screws, using the 5/64-inch ball-end hex driver or T-6 Torx driver, as appropriate (Figure 7-32).

e. Remove the pump latch assembly.

1. First remove the locking set screw on the back of the latch assembly, using a 0.05-inch hex driver (Figure 7-33).
2. Next, loosen the inner locking set screw.
3. Lift the pump latch assembly off the pump shaft.

Figure 7-32. Air-in-line Sensor Mounting Screws

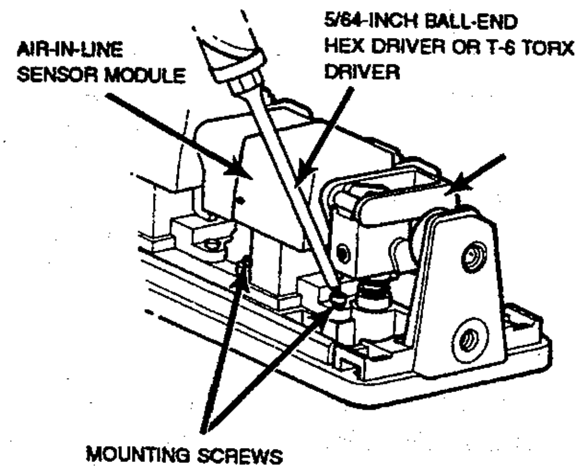
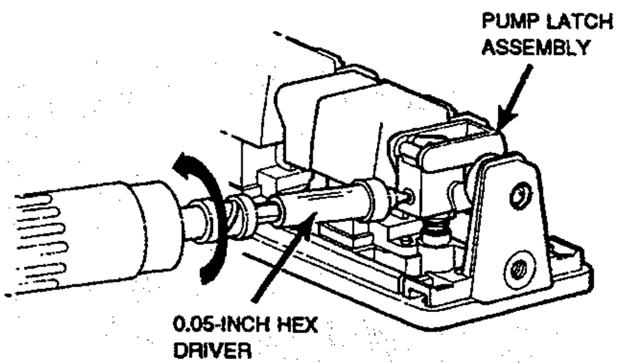


Figure 7-33. Locking Set Screw Removal



f. Inspect for the following.
   1. Pump shaft seal damage (remove the pump shaft seal before inspecting).
   2. Dirt and dried solution on the shaft or sleeve bearing under the seal.
   3. Loose pump shaft sleeve bearings (machined aluminum chassis only).
   4. Impaired slide link movement.
   5. Slide link reflector surface damage.

Reassembly

g. Install the pump shaft seal.
   1. The pump shaft seal may have a short and long end. If so, the shorter end points toward the chassis (Figure 7-34).

h. Install the pump latch assembly.
   1. Position the slide link to allow insertion of the movable jaw pin into the slide link slot (see Figure 7-35).

Figure 7-34. Ends of Pump Shaft Seal

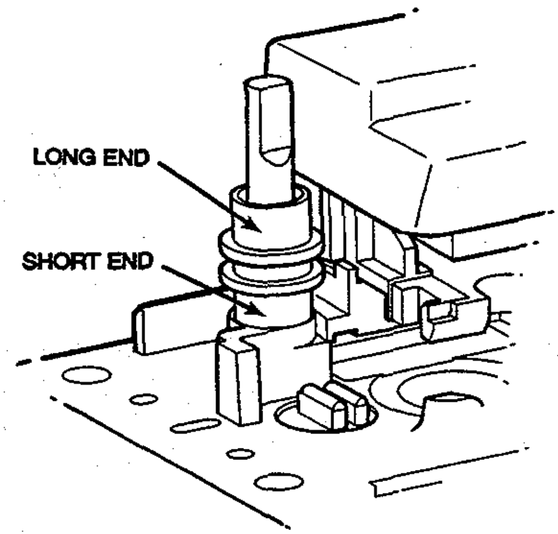
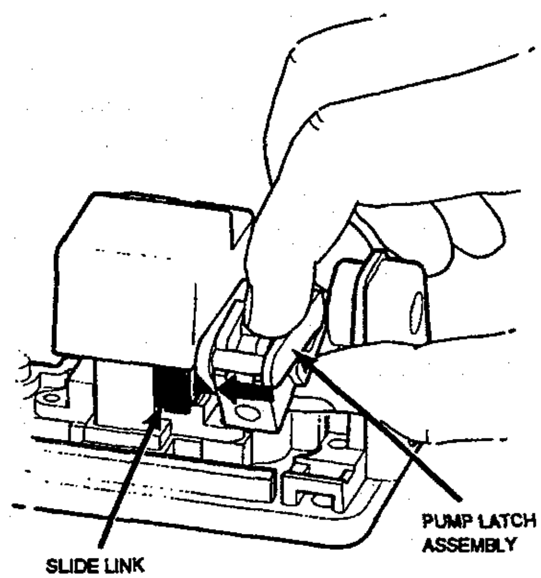


Figure 7-35. Insertion of Movable Jaw Pin into Slide Link Slot

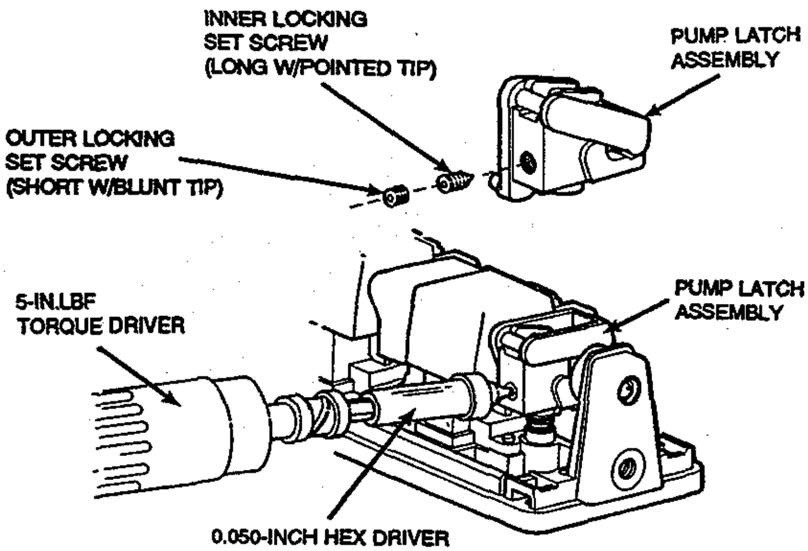


2. Mount the pump latch assembly on the pump shaft. Lightly tighten the inner locking set screw, using a 0.50-inch hex driver (Figure 7-36).

i. Install the air-in-line sensor mounting screws, using a 5/64-inch ball-end hex driver or T6-Torx driver. Tighten to 3 in. lbf.

j. Adjust the pump latch height (Section 7.3.2).

Figure 7-36. Tightening of Locking Screws



k. Reassemble the following in the order listed.
   1. Pole clamp (Section 7.2.1).
   2. MEA (Section 7.5.1).
   3. Backup battery to locking two-pin connector (Section 7.5.3).
   4. Ground wire to chassis (Section 7.5.5).
   5. Display module (Section 7.5.2).
   6. Main housing assembly (Section 7.1.3).
   7. Battery pack (Section 7.1.2).
   8. Lower housing assembly (Section 7.1.1).

l. Recalibrate the sensor systems.
   1. Recalibrate all the sensor systems (Chapter Five).

m. Test.
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter Three) except for the battery check.

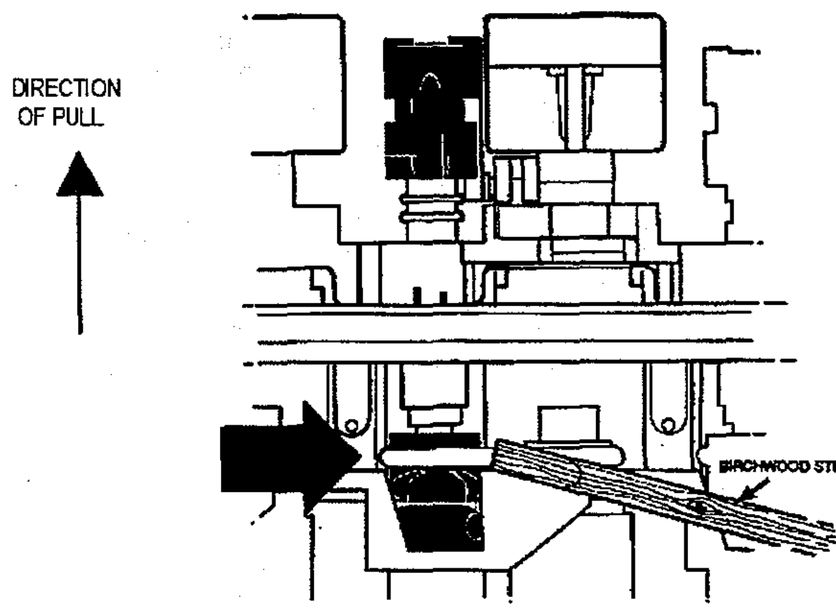
n. Restore the settings.
   1. Using FMS, restore the customized settings and the Battery History Log (refer to the FMS Directions For Use).

7.3.2 Pump Latch Height Adjustment

NOTE: *Gauge blocks are precision instruments. Before they are used, they should be clean and free of any debris. Clean using a lint-free cloth moistened with isopropyl alcohol.*

1. If the instrument is disassembled, rotate each cam until the pump latch assembly is at the closest position to the chassis (Figure 7-37). If the instrument is assembled, remove the lower housing and place the instrument in an upside down vertical position and turn it on. This will *Home* each channel. Pull the pump latch assembly so that the left actuator is switched to the **highest** position (Figure 7-37). Then slowly push down on the pump latch assembly until it stops, without changing the left actuator position. Turn off the instrument.

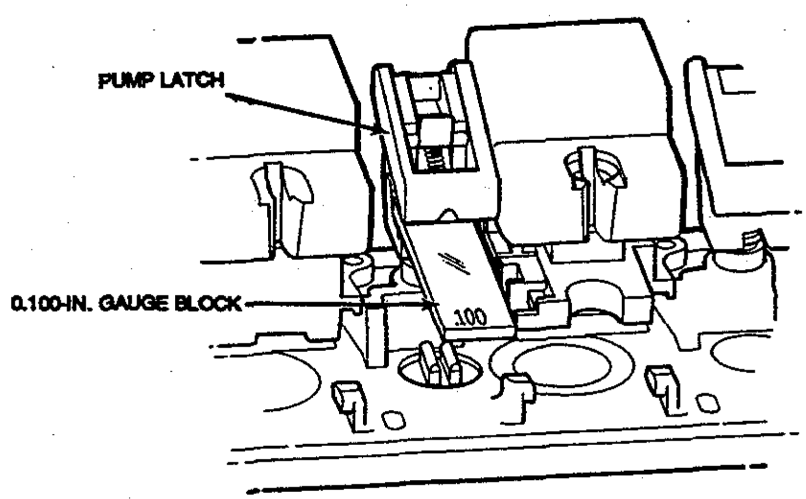
Figure 7-37. Latch Assembly Position Closest to Chassis



NOTE: *When rotating the cam, do not touch with the fingers; use a birchwood stick. Ensure that grease does not come in contact with the belt.*

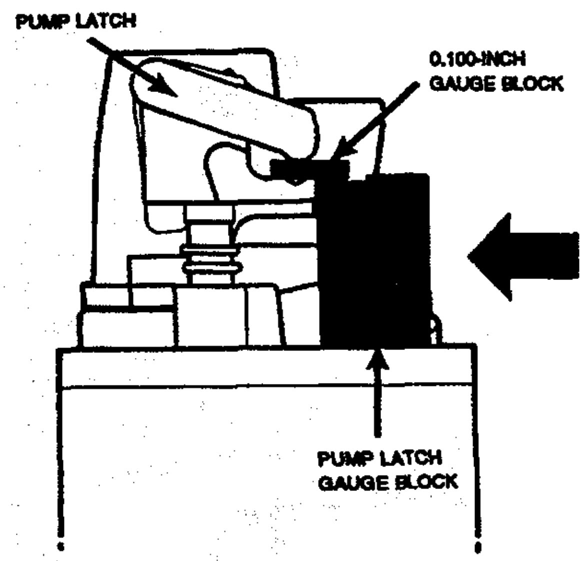
2. Place the 0.100-inch gauge block between the pump latch jaws (Figure 7-38) and close the jaws.

Figure 7-38. Positioning of the 0.100-inch Gauge Block



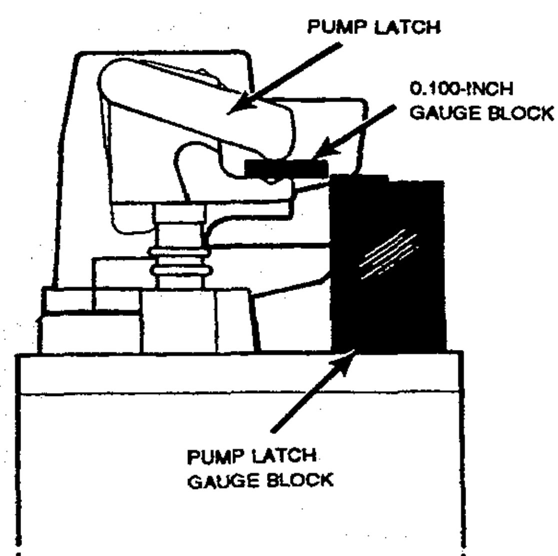
3. Place the pump latch gauge block on the chassis. Ensure that the ridge on the gauge block is on top.
4. Slide the **low** side of the pump latch gauge block under the 0.100-inch gauge block. Stop if any interference is felt, as the pump latch height must be adjusted (Figure 7-39).

Figure 7-39. Low Side of Pump Latch under 0.100-inch Gauge Block



5. Turn the pump latch gauge block around and slide the **high** side of the pump latch gauge block toward the 0.100-inch gauge block. Stop if any interference is felt, as the pump latch height must be adjusted (Figure 7-40).

Figure 7-40. High Side of Pump Latch under 0.100-inch Gauge Block



NOTE: *Gauge blocks dimensions should be verified annually to ensure optimum performance. The distance between the bottom and the **low** side of the pump latch gauge block is 0.7580 + 0.0004 or - 0.0000 inches. The distance between the bottom and the **high** side of the pump latch gauge block is 0.7620 + 0.0000 or - 0.0004 inches. If dimensions are incorrect, the gauge blocks should be replaced.*

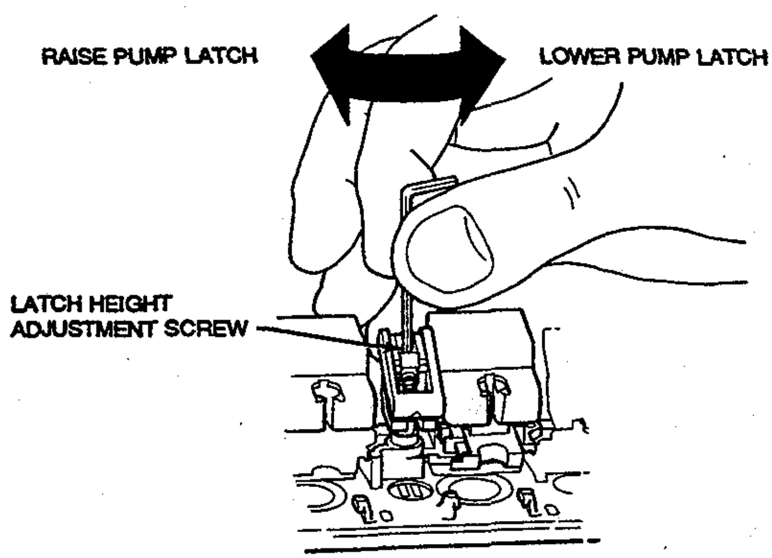
6. The following table shows the gauge conditions that indicate whether or not the pump latch height is within specification.

Table 7-1. Gauge Conditions for Pump Latch Height Specifications

(Low Side) Minimum	(High Side) Maximum	Within Specification
Go	Stop	Yes
Go	Go	No
Stop	Stop	No

7. If the pump latch height is not within specification, use the 0.050-inch Allen key to turn the height adjustment screw on the latch (Figure 7-41). This screw raises (turned clockwise) or lowers (turned counterclockwise) the pump latch.

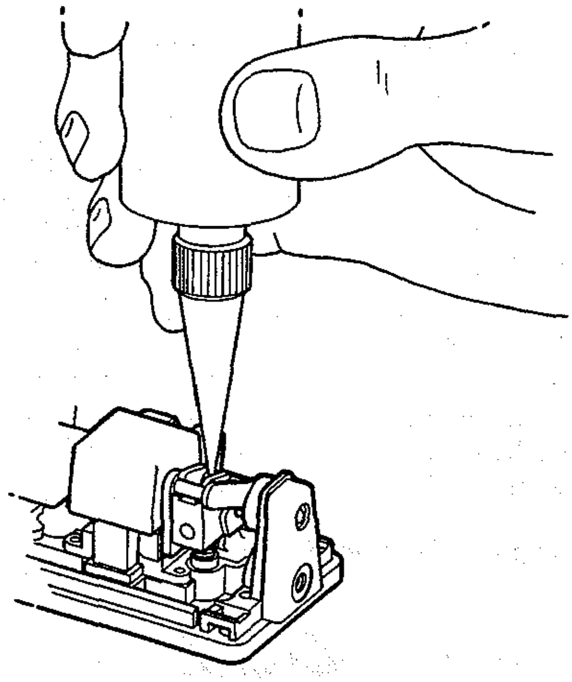
Figure 7-41. Latch Height Adjustment Screw



8. Repeat the procedure and adjustment until the height is within specification.
9. Tighten the inner locking set screw to 5 in. lbf, using the 0.05-inch hex driver (Figure 7-36).
10. Install the outer locking set screw and tighten to 5 in. lbf (Figure 7-36).
11. Apply a small drop of Loctite® Assure 425 to the latch height adjustment screw (Figure 7-42). Take care not to drip excess adhesive on any other parts.

NOTE: *Use only Loctite Assure 425 on the pump latch height adjustment screw. Do not substitute other agents, as they can damage the plastic components. Do not use the threadlocker in any other location.*

Figure 7-42. Loctite Assure 425 Application



7.3.3 Pump Latch Movable Jaw Repair

Tools required:

- Small flat blade screwdriver
- Tweezers

Disassembly

a. First, remove the following.
   1. Lower housing assembly (Section 7.1.1).

b. Remove the movable jaw, spring, and seat.

   Attach the instrument firmly to a table and rotate it until the pump latches are facing up. *Home* the pump latch by turning the instrument on with no cassette installed. The latch should now be in the closest position to the chassis. Turn the instrument off.

   1. Close the pump latch movable jaw (Figure 7-43).
   2. Insert a small screwdriver under the pivot bar on the upper rear part of the movable jaw (Figure 7-44).
   3. Slowly pry the pivot bar up and back to clear the stationary jaw.

Figure 7-43. ***Pump Latch Movable Jaw Closure***

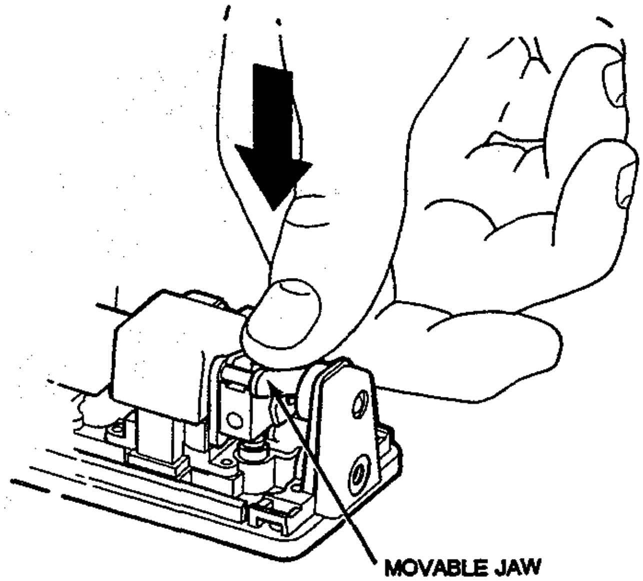
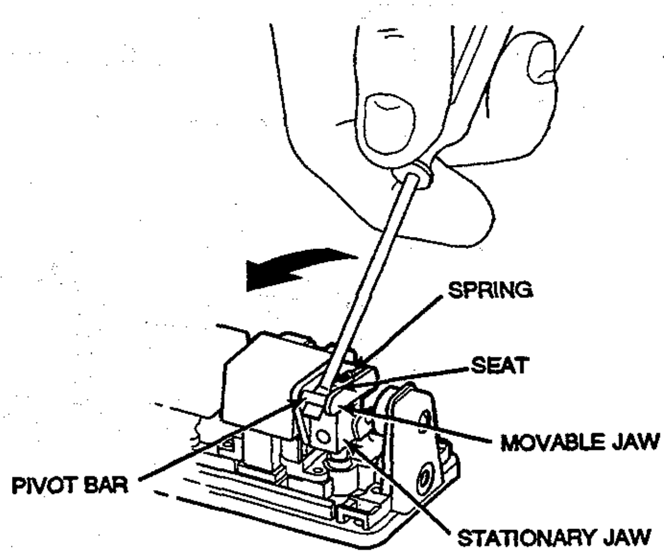
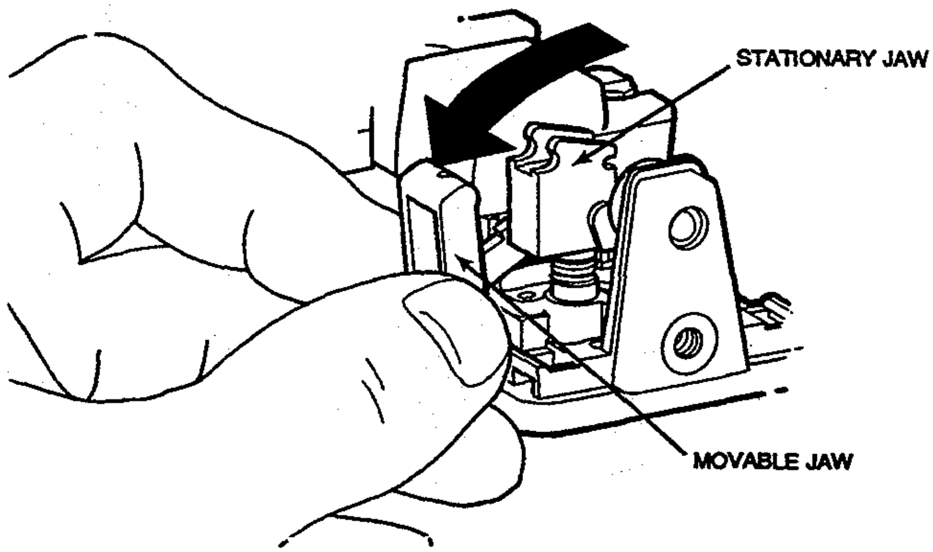


Figure 7-44. ***Movable Jaw Separation***



4. Using tweezers, remove the spring and seat.
5. Rotate the movable jaw back 90 degrees to clear the stationary jaw (Figure 7-45).
6. Slide the movable jaw to the side away from the pump latch, using a slight twisting motion to release it from the slide link.

Figure 7-45. Movable Jaw Removal

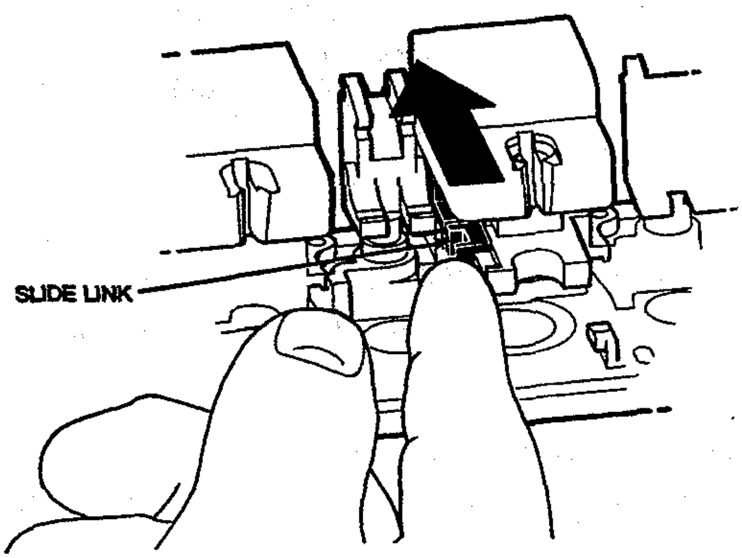


Reassembly

a. Reassemble the movable jaw, spring, and seat.

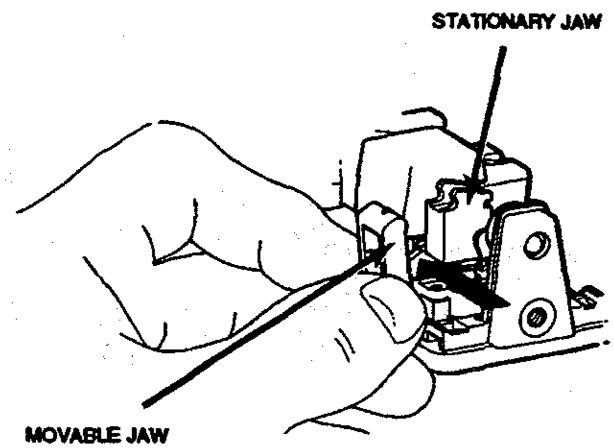
1. Position the slide link all the way to the rear of the instrument (Figure 7-46).

Figure 7-46. Slide Link Position for Movable Jaw Reassembly



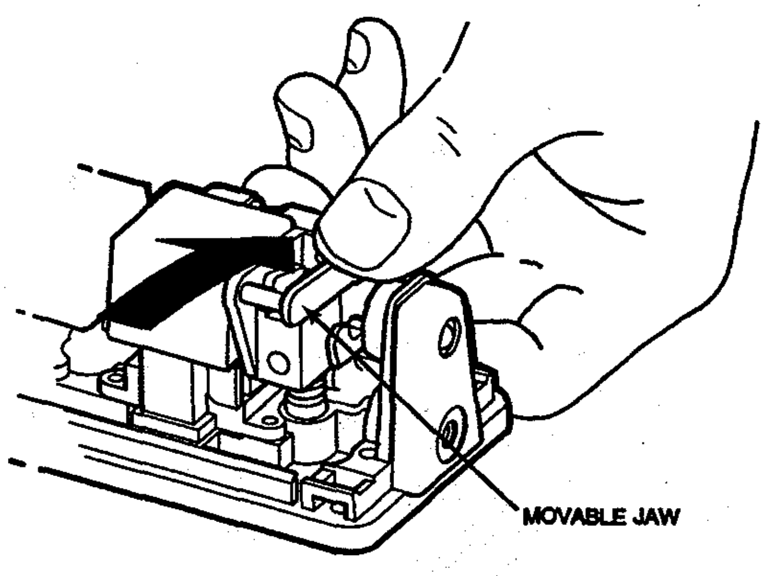
2. Insert the movable jaw pin into the slide link slot (Figure 7-47).

Figure 7-47. Movable Jaw Pin Insertion



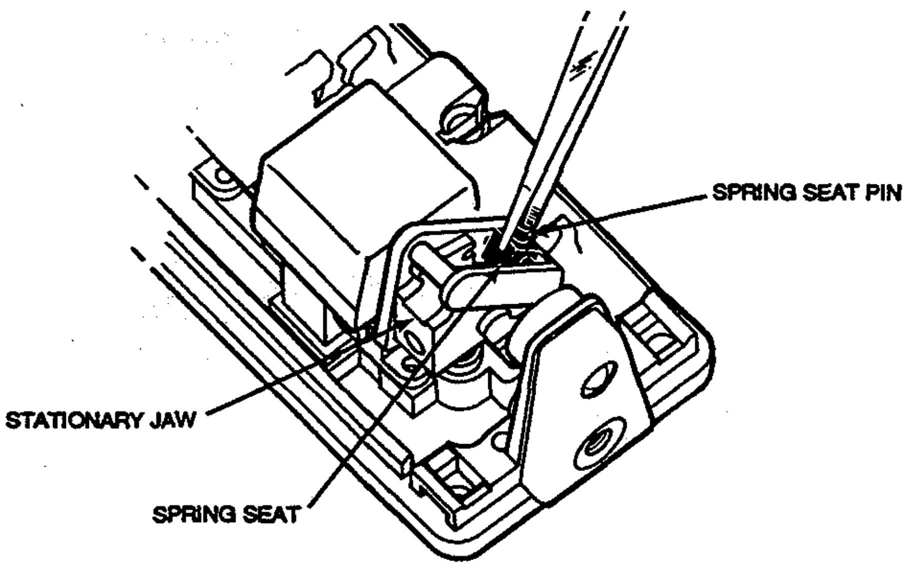
3. Rotate the movable jaw to the lowest position (Figure 7-48).

Figure 7-48. Movable Jaw Rotation for Reassembly



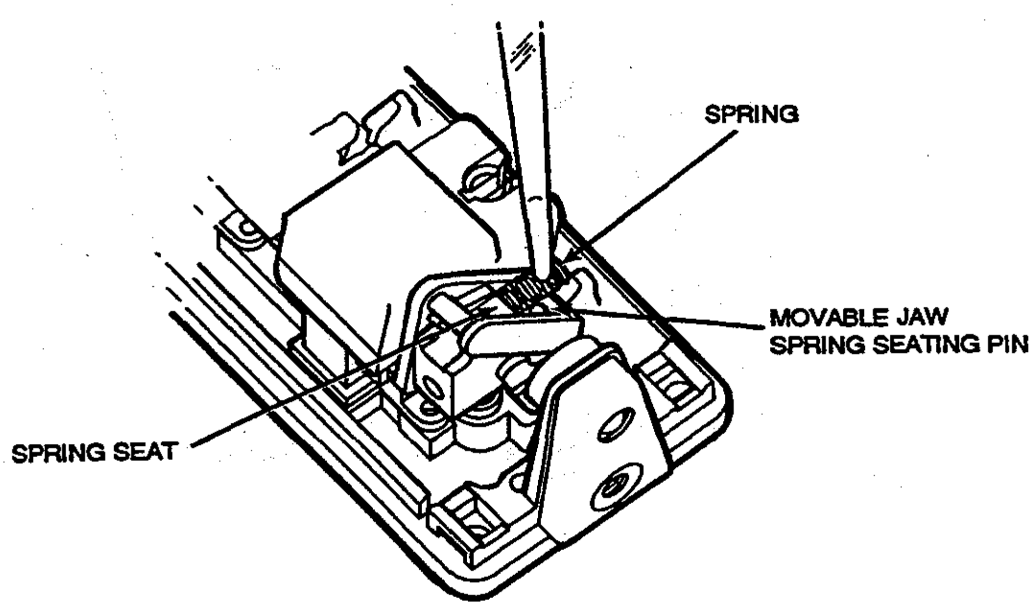
4. Install the spring seat onto the stationary jaw (Figure 7-49) so that the angled portion of the seat faces the chassis and the spring seat pin points forward.

Figure 7-49. Spring Seat Installation



5. Using tweezers, place the spring over the seat pin (Figure 7-50).

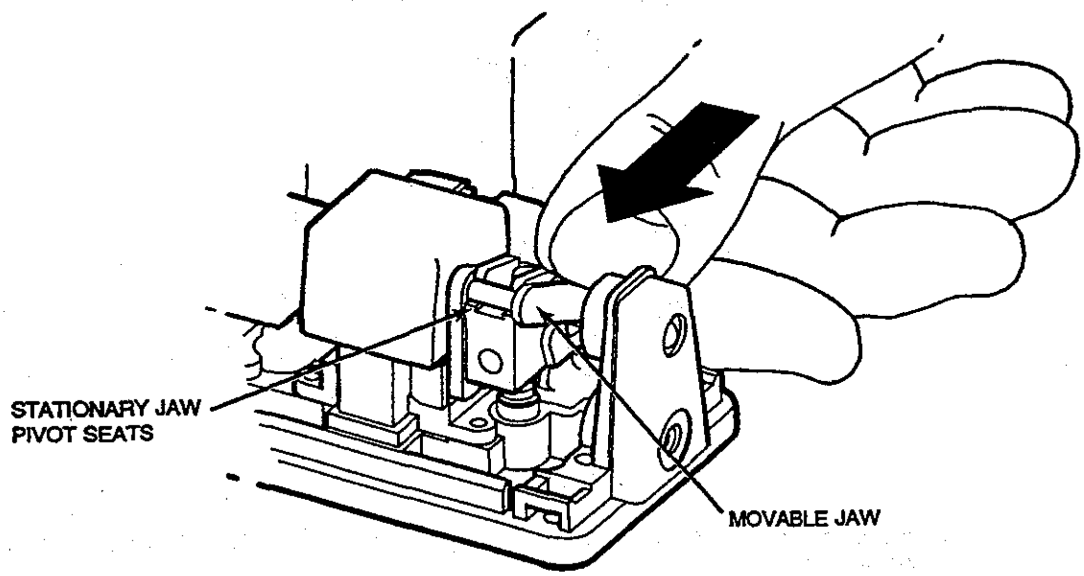
Figure 7-50. Latch Assembly Spring Placement



6. Position the movable jaw spring seating pin against the spring.

7. Compressing the spring, rotate the movable jaw into the stationary jaw pivot seats (Figure 7-51).

Figure 7-51. Spring Compression and Movable Jaw Rotation



b. Check the following.

1. Turn the instrument on.
2. Open and close the movable jaw to ensure proper operation of the latch and slide link.
3. Verify that the software recognizes latch closure. Check for *Closed Pump Latch* advisory.
4. Leave the pump latch in the open position.

c. Reattach the lower housing assembly (Section 7.1.1).

7.3.4 Slide Link Repair

Tools required:

- 5/64-inch ball-end hex driver or T-6 Torx driver
- 3 in. lb torque driver
- Small flat blade screwdriver
- Tweezers

Disassembly

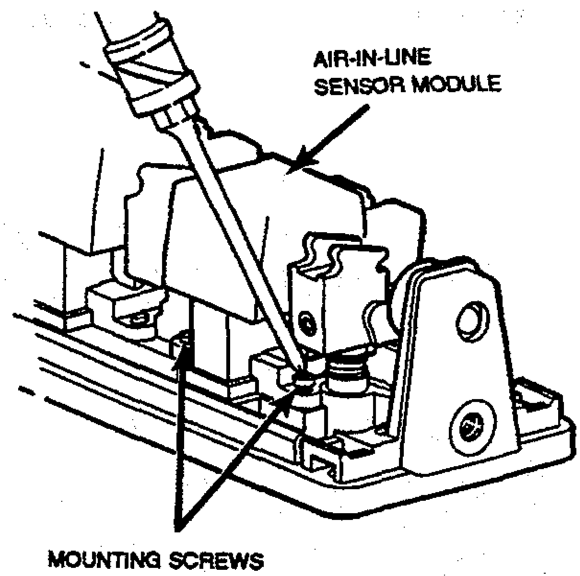
a. First, remove the following.

1. Lower housing assembly (see Section 7.1.1).
2. Pump latch movable jaw (Section 7.3.3).

Remove the slide link:

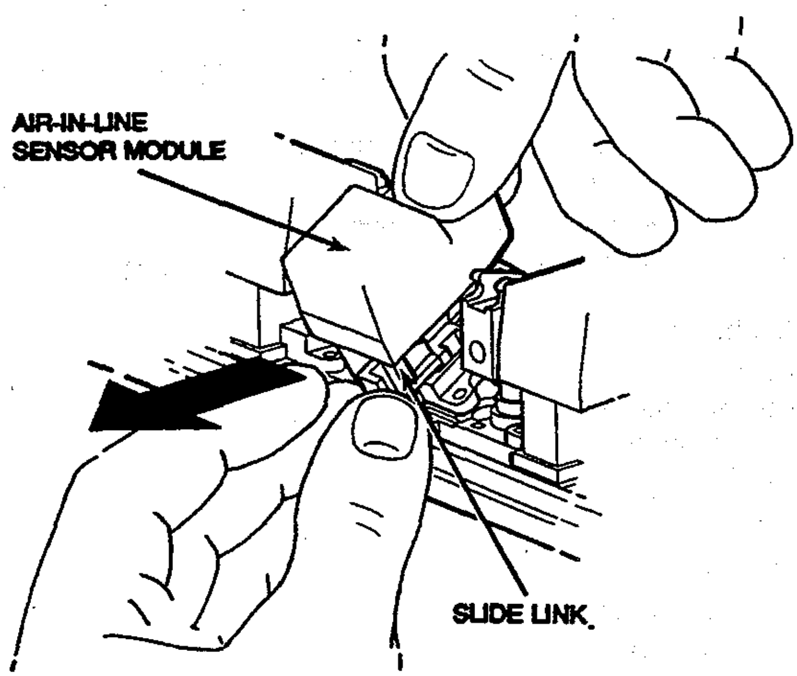
(a) Loosen the air-in-line sensor mounting screws with the 5/64-inch ball-end hex driver or the T6-Torx driver, as appropriate (Figure 7-52).

Figure 7-52. Air-in-line Sensor Mounting Screws



(b) Slightly lift the sensor module so that the slide link clears the optomodule (Figure 7-53).

Figure 7-53. Slide Link Removal



(c) Be careful not to disconnect the air-in-line sensor module from the MEA by lifting too far.

(d) Remove the slide link toward the rear of the instrument.

CAUTION

Do not touch the reflective surface on the bottom of the slide link, as skin oils may contaminate the surface. The slide link track requires NO lubrication.

b. Inspect for the following.

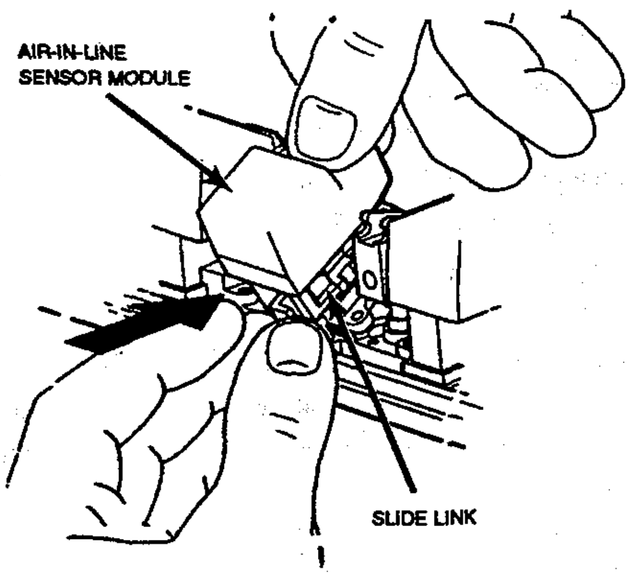
1. Defects, dried solution, or dirt on the reflector surface.
2. Dried solution and dirt on the optomodule and air-in-line sensor.

Reassembly

a. Reinstall the slide link.

1. Insert the slide link (Figure 7-54) into place by tilting the air-in-line sensor module to clear the optomodule.
2. Slide the slide link forward to ensure proper movement on the track.

Figure 7-54. Slide Link Replacement



3. Tighten the air-in-line sensor mounting screws to 3 in. lbf, using the 5/64-inch ball-end hex driver or T-6 Torx driver.
4. Reassemble the movable jaw, spring, and seat (Section 7.3.1).
5. Reattach the lower housing assembly (Section 7.1.1).

b. Recalibrate the cassette and latch sensors (Chapter 5).

c. Test.

1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

7.3.5 Drive Module Assembly Repair

WARNING

Whenever the drive module is removed and reinstalled, the valve actuator and pump latch height must be verified and, if necessary, adjusted. This is a critical step and must be performed to ensure safety, as well as proper functioning of the instrument.

Tools required:
- #1 Phillips screwdriver
- 3/32-inch hex driver
- 5/16-inch flat blade screwdriver
- Chassis holding stand
- 0.05-inch Allen key
- 0.05-inch hex driver
- 5 in. lbf torque driver
- Lint-free swabs
- Magnalube-G Teflon grease
- Loctite® Assure 425 surface curing threadlocker
- Gauge block kit

Disassembly

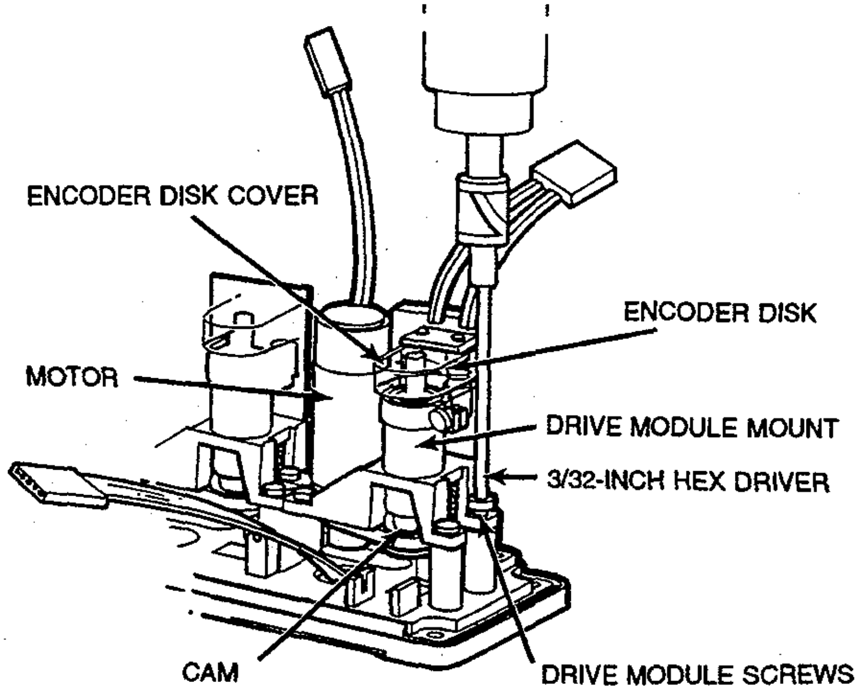
a. First, remove the following.
   1. Lower housing assembly (Section 7.1.1).
   2. Battery pack (Section 7.1.2).
   3. Main housing assembly (Section 7.1.3).
   4. Display module (Section 7.5.2).
   5. Pole clamp assembly (Section 7.2.1).
   6. Ground wire from the chassis (Section 7.5.5).
   7. Backup battery from the locking two-pin connector (Section 7.5.3).
   8. All motor, encoder, and pressure transducer connections from the MEA (Section 7.4.2).

b. Remove the drive module assembly.
   1. Remove the three drive module mounting screws, using a 3/32-inch hex driver (Figure 7-55).

   NOTE: *Ensure the belt and pulleys aren't contaminated with grease or skin oils.*

c. Inspect for:
   1. Drive belt that is worn, cracked or contaminated with grease.
   2. Broken wires or connectors.
   3. Damaged encoder disk or disk cover (Figure 7-55).
   4. Cracked or broken drive module mounts.
   5. Pump shaft bearing not seated (Model 2860 only).
   6. Corrosion.

Figure 7-55. Drive Module Screw Removal



d. Ensure the following.
   1. The motor is secured firmly to drive module.
   2. The cam is secured firmly.

> **WARNING**
>
> *The alignment of the cam to the encoder is critical for proper fluid delivery; therefore, do not repair defective modules. Defective modules must be replaced. (The motor can be replaced and is part of the module.)*

   3. The motor and cam turn freely in one direction (remove the drive belt to test).
   4. The one-way clutch within the drive module assembly allows cam rotation in only one direction.

Reassembly

a. Replace the motor.
   1. Remove the drive belt (see Figure 7-56).
   2. Loosen the motor mounting screws that retain the motor, using the #1 Phillips and flat blade screwdrivers (Figure 7-57).
   3. Rotate the cleats so that the "flats" face the motor (Figure 7-58).
   4. Noting orientation (Figure 7-58), remove and replace the motor.
   5. Rotate the cleats to the previous locking position.

Figure 7-56. Drive Belt Removal

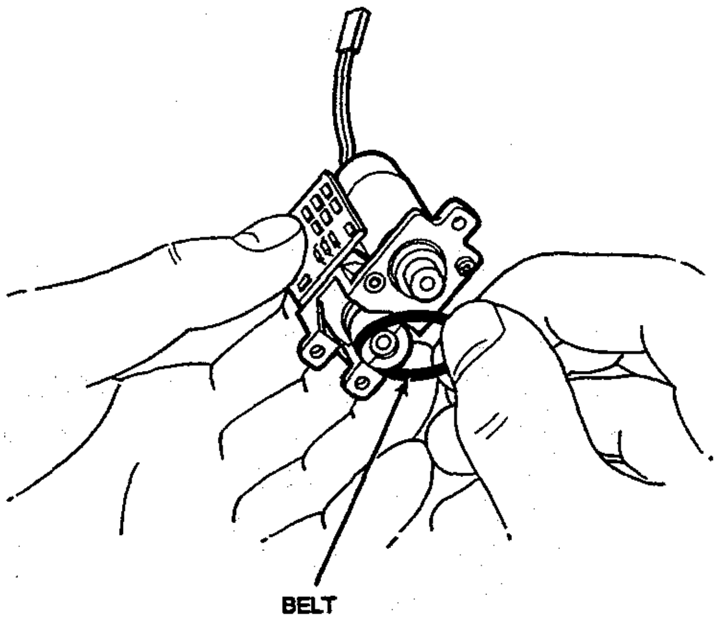
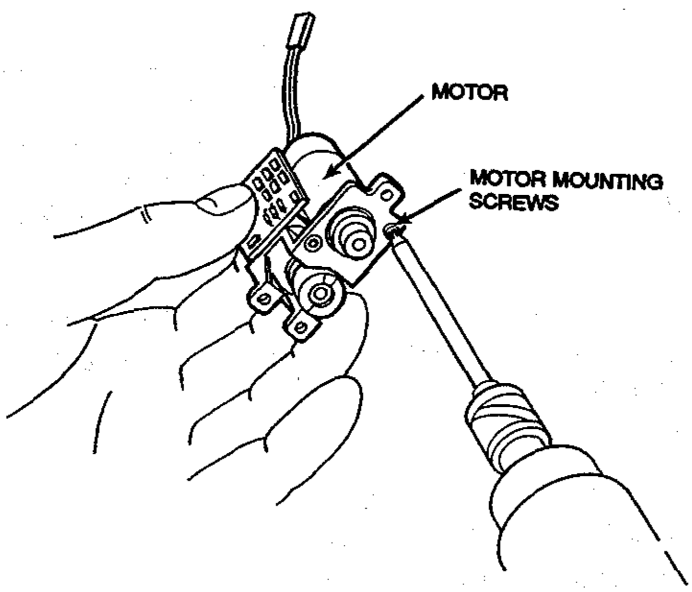
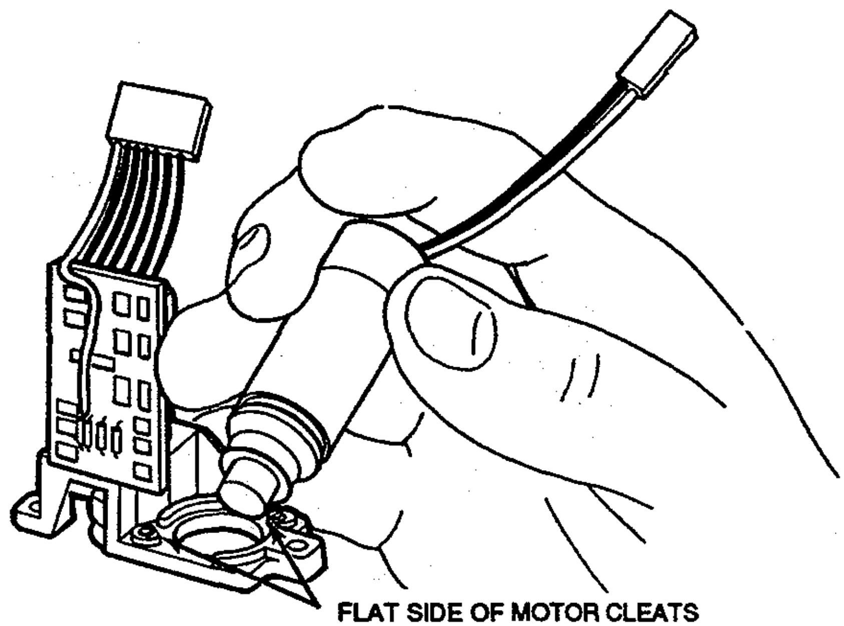


Figure 7-57. Motor Mounting Screws



6. Tighten the mounting screws.
7. Attach the drive belt.

Figure 7-58. Motor Cleat Rotation



b. Replace the encoder or motor connector/wires.

1. A Connector Kit, which can be ordered, contains the required encoder and motor connector shells, and wires crimped with receptacles.
2. If heat shrink tubing is used to repair wires, do not apply direct heat to the drive module assembly. The assembly can be easily damaged.
3. If the wires are resoldered to the encoder, be sure to reapply epoxy around the solder pads.
4. The epoxy acts as a strain relief and helps prevent the wires from breaking (see Figure 7-59).
5. Ensure that the replacement wire is the proper length.
6. Ensure the proper orientation of the connector and wires during replacement (see Figure 7-59).

c. Clean and lubricate the cam.

NOTE: *Be sure that the belt and pulleys are not contaminated with grease or skin oils.*

1. Using a lint-free swab and isopropyl alcohol, clean the surface of the cam that contacts the valve actuator bearings (Figure 7-60). Clean the slot in the cam that drives the pump shaft follower. Also, clean the pump shaft follower bearings and the valve actuator bearings (Figure 7-60).
2. Using a clean lint-free swab, apply a thin film of Magnalube-G Teflon grease to the cam face and slot.

Figure 7-59. Drive Module Assembly Wire Orientation

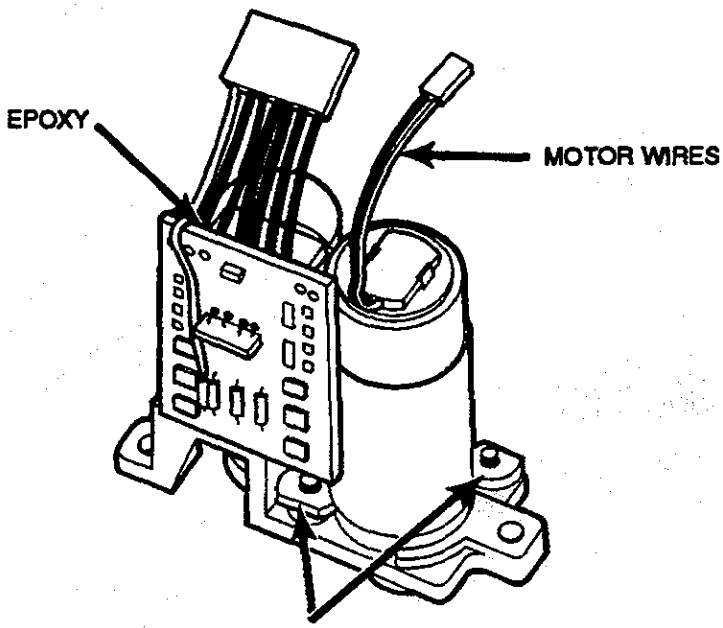
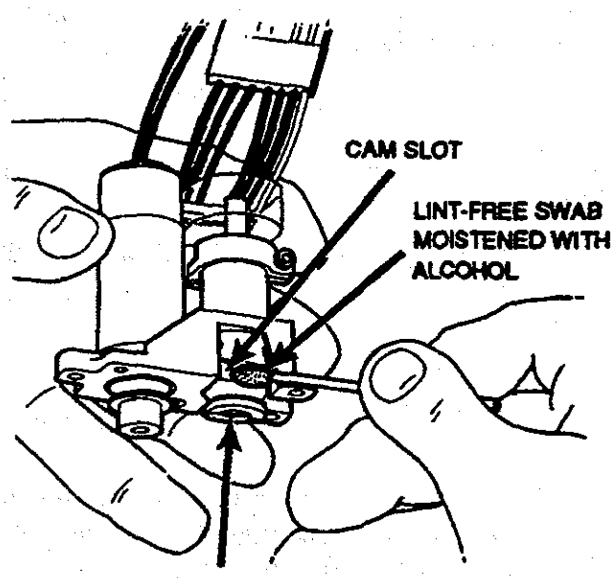
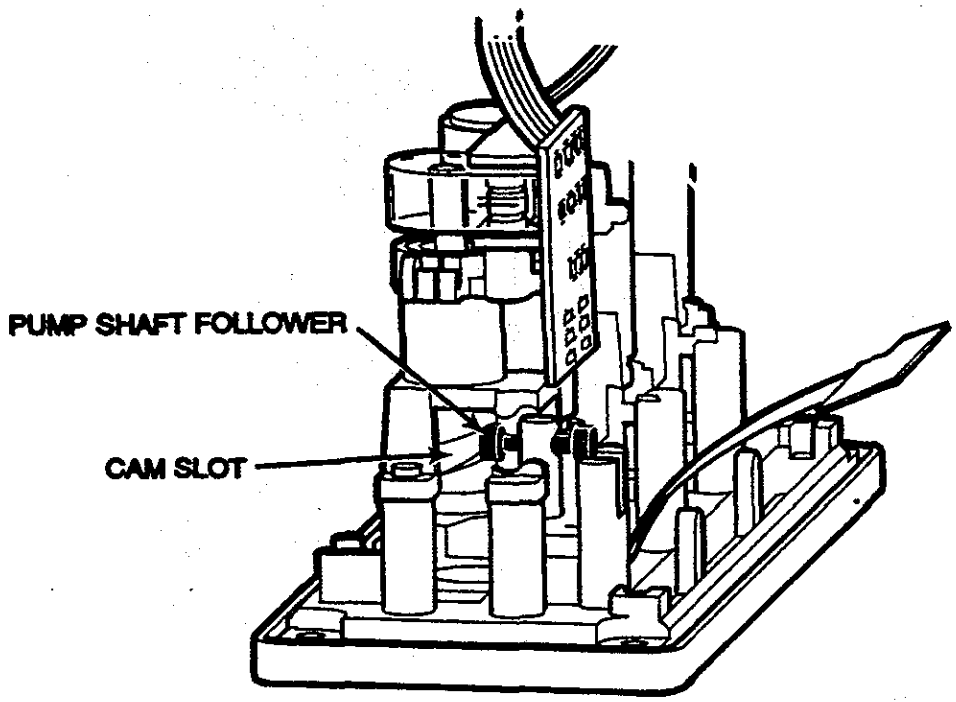


Figure 7-60. Cleaning the Cam



3. Ensure that the motor wires are oriented toward the rear of the drive module (Figure 7-59). If not, loosen the motor screws and realign.
4. Align the pump shaft cam follower with the cam slot (Figure 7-61).

Figure 7-61. Pump Shaft Cam Follower Adjustment



5. Position the drive module on the chassis.
6. Install the drive module mounting screws, using a 3/32-inch hex driver or a #1 Phillips screwdriver, as appropriate. Tighten to 5 in. lbf torque.

WARNING

If any chassis threads are stripped, do not attempt to repair them. The chassis must be replaced. Free-flow or inaccurate fluid delivery can result from a drive module that is not properly secured. Should chassis replacement be necessary, return the instrument to the factory for repair.

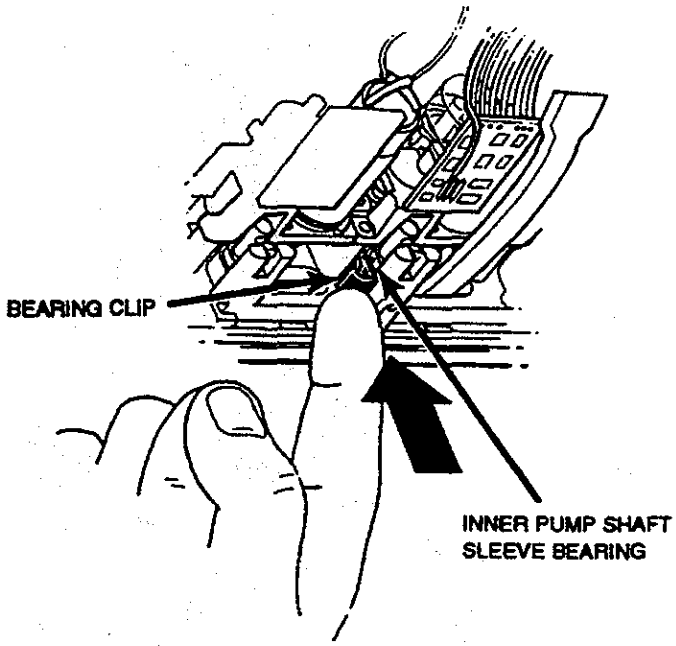
7. For Model 2860, install bearing clips to retain the inner pump shaft sleeve bearing (Figure 7-62). Make sure that the clips are properly installed. One loud, then one soft, click should be heard as clips are pushed in; and clips should be immobile.

   NOTE: *Do not reuse bearing clips.*

d. Ensure the following.

1. The assembly operates by applying 5VDC (9mA minimum) power to the motor terminals.
2. Connect the positive to the red wire; otherwise, the one-way clutch will prevent movement.

Figure 7-62. Bearing Clip Installation (Model 2860 only)



e. Verify the valve actuator heights using the procedure described in Section 7.3.6.

f. Adjust the pump latch height.

   1. Adjust the pump latch height using the procedure described in Section 7.3.2.

Reassembly

a. Reassemble in the following order.

   1. Pole clamp (Section 7.2.1).
   2. MEA (Section 7.5.1).
   3. Backup battery to locking two-pin connector (Section 7.5.3).
   4. Ground wire to chassis (Section 7.5.5).
   5. Display module (Section 7.5.2).
   6. Main housing assembly (Section 7.1.3).
   7. Battery pack (Section 7.1.2).
   8. Lower housing assembly (Section 7.1.1).

b. Recalibrate.

   1. All the sensor systems must be recalibrated (Chapter 5).

c. Test.

   1. Perform run-in (Section 7.1) and all the functional checks.

d. Restore the settings.

   1. Using FMS, restore the customized settings and the Battery History Log. (Refer to the FMS Directions For Use.)

7.3.6 Valve Actuator Height Verification

NOTE: *Gauge blocks are precision instruments. Before they are used, they should be clean and free of any debris. Clean using a lint-free cloth moistened with isopropyl alcohol.*

a. Assemble the chassis holding stand (Section 7.1).

b. Remove the pole clamp. Carefully lift the MEA, which has the power supply PCBA attached to it, from the chassis guides. Attach the chassis to the chassis holding stand with the drive modules facing down. Position the MEA and attached power supply PCBA away from the chassis stand so that it allows for correct placement of the chassis (Figure 7-63).

c. Rotate each cam until the right valve actuator is at the highest position above the chassis (Figure 7-64).

d. If the instrument is assembled, place it in an upside-down, vertical position and turn it on. This will "Home" each channel and place the right valve actuators at the highest position (Figure 7-64). Turn the instrument off.

e. Place the valve actuator gauge block, marked MIN, on the chassis in front of the valve actuators. Make sure that the high side of the gauge aligns with the high valve actuator (Figure 7-65).

f. Move the valve actuator gauge block so that it rests along the cassette guide.

g. Gently slide the valve actuator gauge block along the chassis toward the pump shaft until:

   1. it slides over the valve actuators, or
   2. interference is felt when the valve actuator gauge block comes in contact with the valve actuators.

h. Repeat the steps with the valve actuator gauge block marked MAX.

i. The following table shows the gauge conditions that indicate whether or not the valve actuator heights are within specification.

Table 7-2. Gauge Conditions for Valve Actuator Height Specifications

(Low Side) Minimum	(High Side) Maximum	Within Specification
Stop	Go	Yes
Go	Go	No
Stop	Stop	No

NOTE: *The distance (in inches) between the bottom and each side of the minimum and maximum valve actuator gauge block is as follows.*

Figure 7-63. ***Attachment of Chassis to Holding Stand***

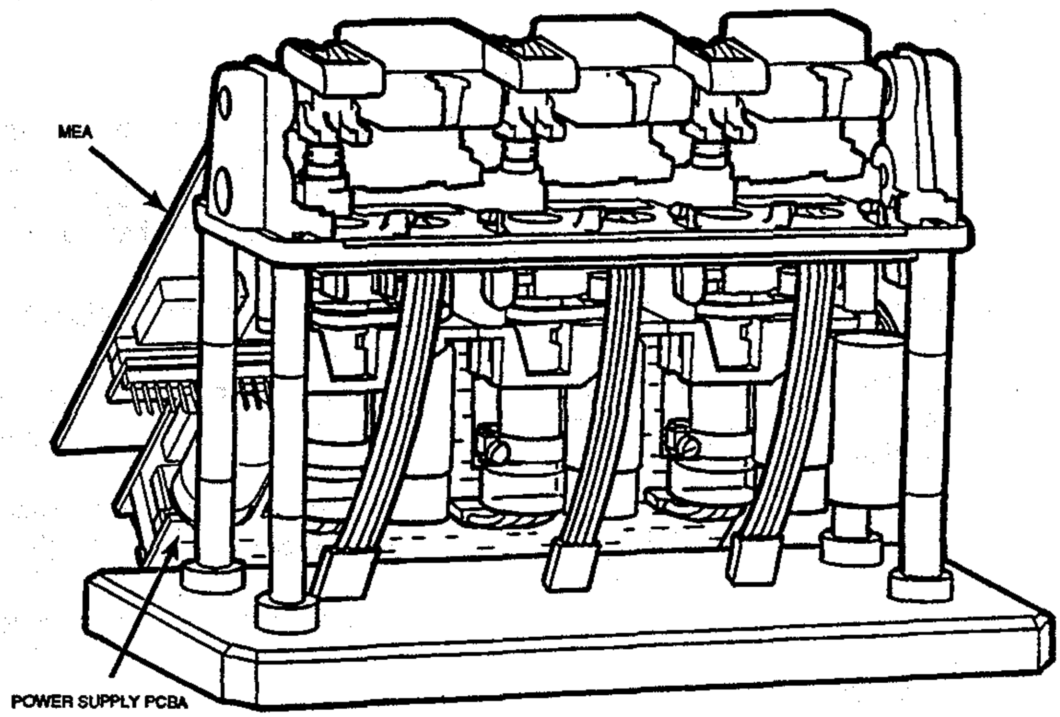
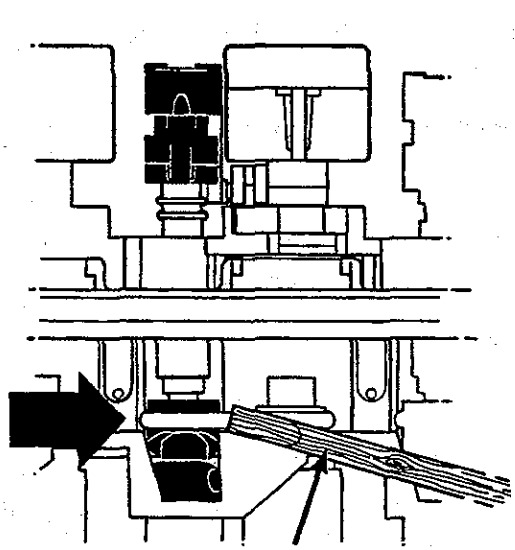
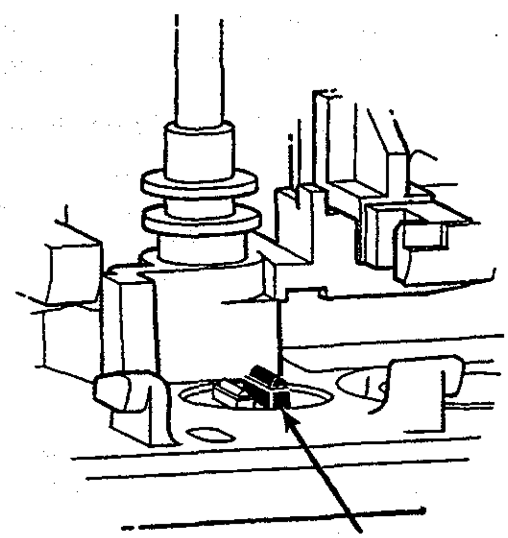


Figure 7-64. ***Right Valve Actuator at Highest Position***

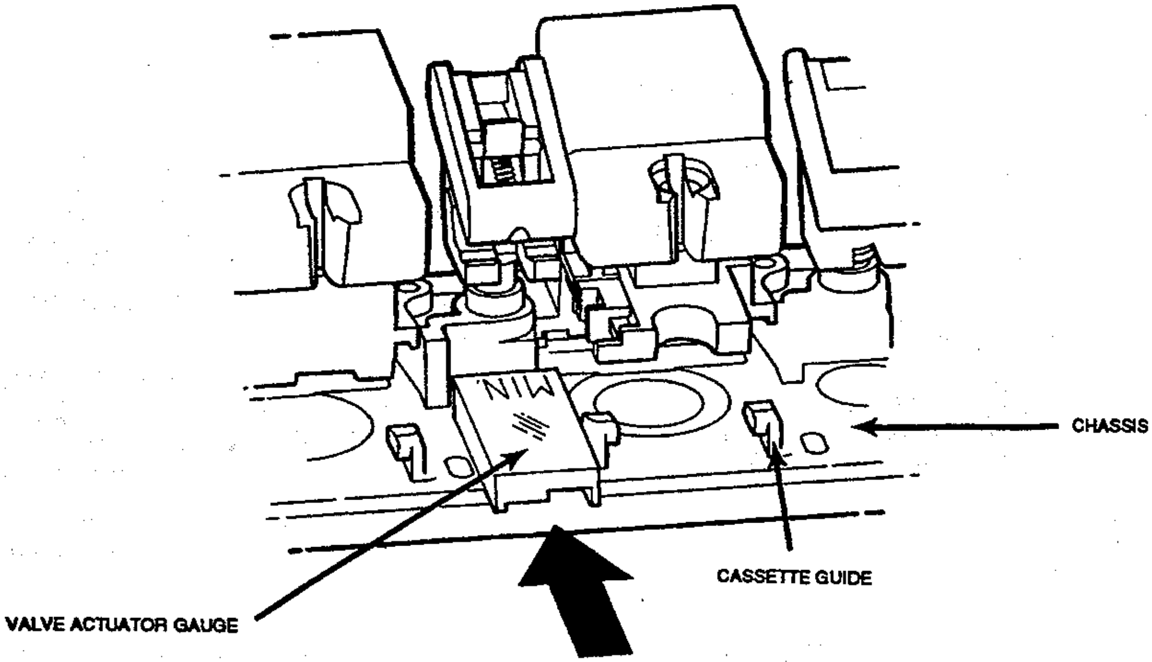


A. ADJUSTING VALVE ACTUATOR.



B. VALVE ACTUATOR IN HIGHEST POSITION.

Figure 7-65. Placement of Valve Actuator Gauge Block on Chassis



Bottom to High Side:
Minimum is 0.0700 + 0.0000 / - 0.0005
Maximum is 0.0750 + 0.0005 / - 0.0000

Bottom to Low Side:
Minimum is 0.0300 + 0.0000 / - 0.0005
Maximum is 0.0340 + 0.0005 / - 0.0000

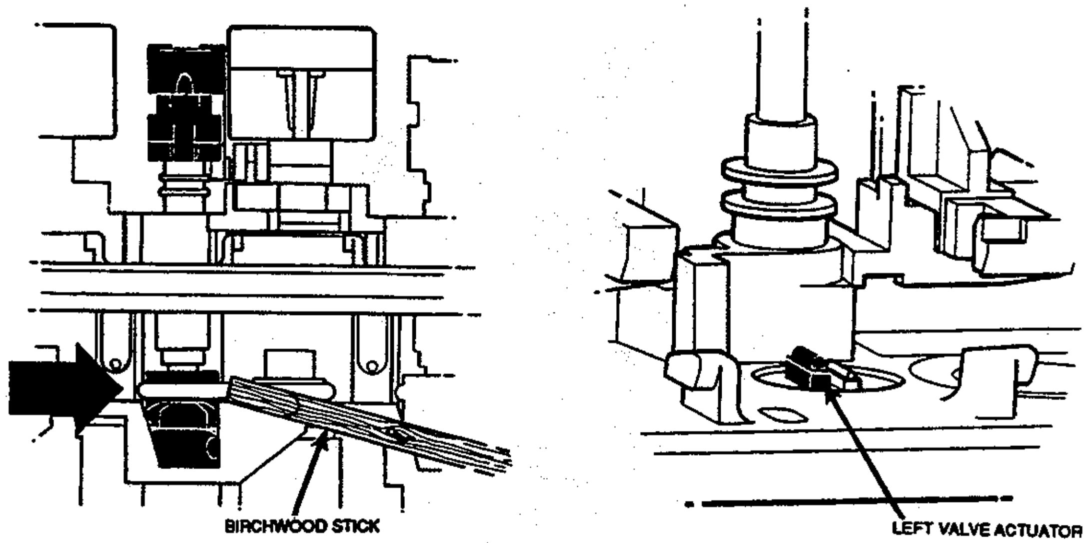
j. If the measurements are not within specification, complete the following steps.
   1. Loosen the three drive module mounting screws, using a 3/32 hex driver.
   2. Reseat the drive module.
   3. Tighten the screws to 5 in. lbf torque.
   4. Remeasure the valve actuator heights. If the measurements remain out of specification, replace the valve actuators.

k. After verifying that the right valve actuator heights are within specification, rotate the cam until the left valve actuator is at the highest position above the chassis (see Figure 7-66).

l. If the instrument is assembled, quickly pull the pump latch away from the chassis until the left actuator is at the highest position above the chassis (Figure 7-67).

m. Repeat the previous steps to measure the heights for the left valve actuator.

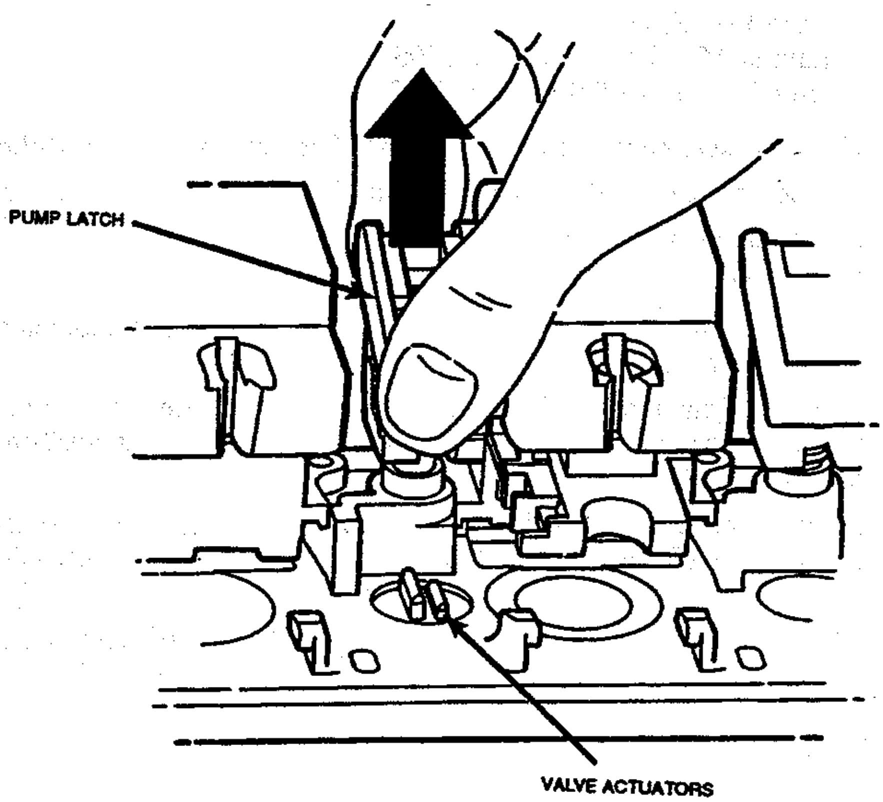
Figure 7-66. Left Valve Actuator in Highest Position



A. ADJUSTING VALVE ACTUATOR.

B. VALVE ACTUATOR IN HIGHEST POSITION.

Figure 7-67. Positioning Left Actuator in Highest Position when Instrument is Assembled



7.3.7 Pump Shaft

Whenever the drive module is removed and reinstalled, the valve actuator and pump latch height must be verified and, if necessary, adjusted. This is a critical step and must be performed to ensure safety, as well as proper functioning of the instrument.

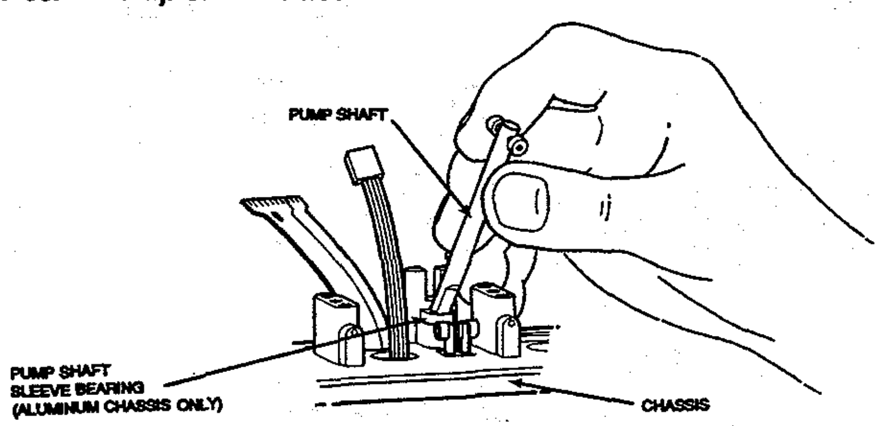
Tools required:
- #1 Phillips screwdriver
- 3/32-inch hex driver
- 5/16-inch flat blade screwdriver
- Lint-free swabs
- Magnalube-G Teflon grease
- Chassis stand
- Gauge block assembly kit
- Loctite® Assure 425 surface curing threadlocker
- 0.050-inch Allen key
- 0.050-inch hex driver

Disassembly

a. First, remove the following.
   1. Lower housing assembly (Section 7.1.1).
   2. Battery pack (Section 7.1.2).
   3. Main housing assembly (Section 7.1.3).
   4. Display module (Section 7.5.2).
   5. Power supply PCBA (Section 7.5.5).
   6. (Model 2860 only) MEA (Section 7.5.6).
   7. Pump latch assembly (Section 7.3.1).
   8. Drive module assembly (Section 7.3.4).

b. Remove the shaft.
   1. After the pump latch and drive module assemblies are removed, the pump shaft can be removed from the chassis (Figure 7-68).

Figure 7-68. Pump Shaft Removal



c. Inspect for the following.

1. Dirt or dried solution on the pump shaft bearing surfaces (Model 2860 only).
2. Damaged pump shaft seal.
3. Loose pump shaft bearings on the chassis (Model 2860 only).

d. Ensure the following.

1. The pump shaft bearings rotate smoothly without excessive play.

e. Pump shaft repair and installation.

1. Aluminum or diecast chassis with sleeve bearing (see Figure 7-69 and 7-70)

   (a) Clean the pump shaft sleeve bearings.

Figure 7-69. Machined Aluminum Chassis with Sleeve Bearings (Model 2860)

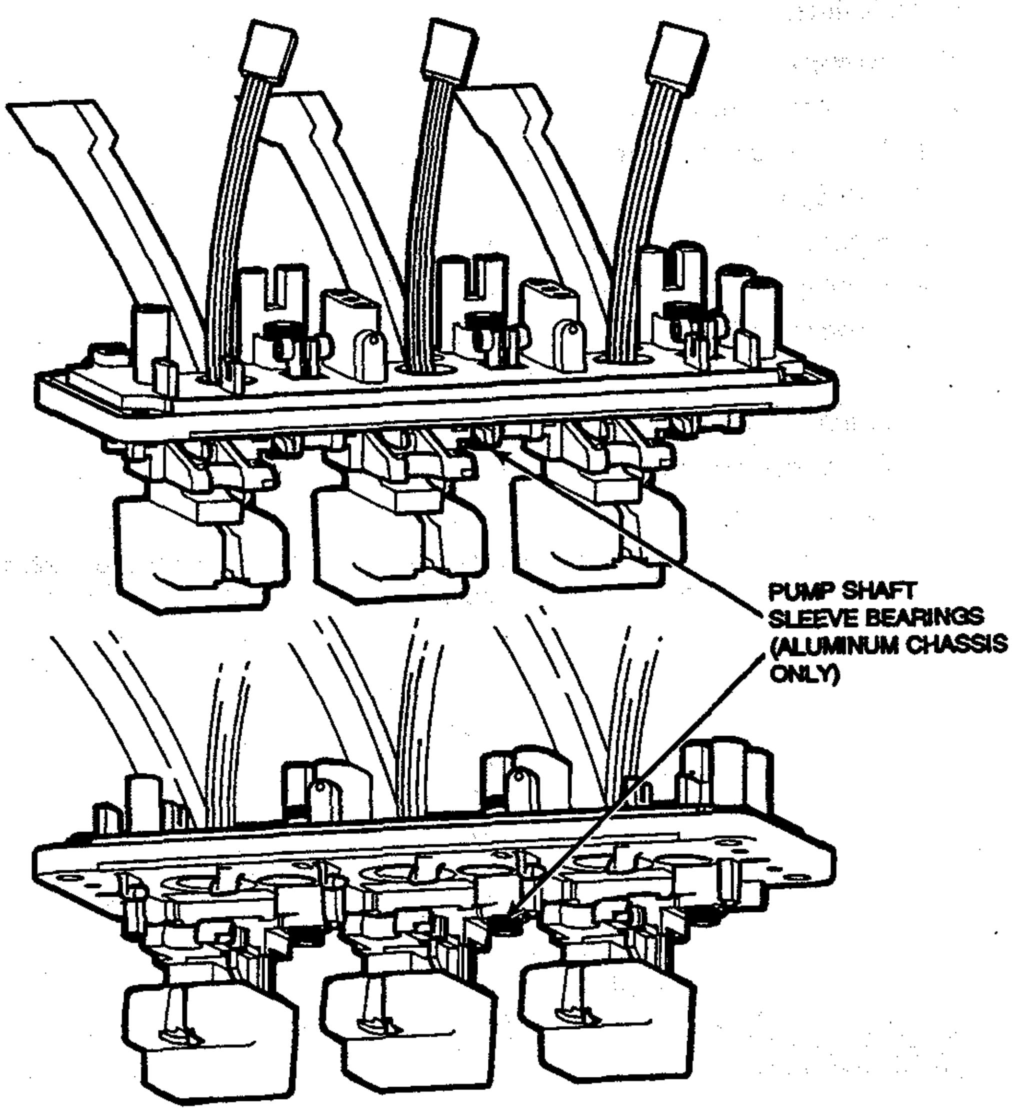
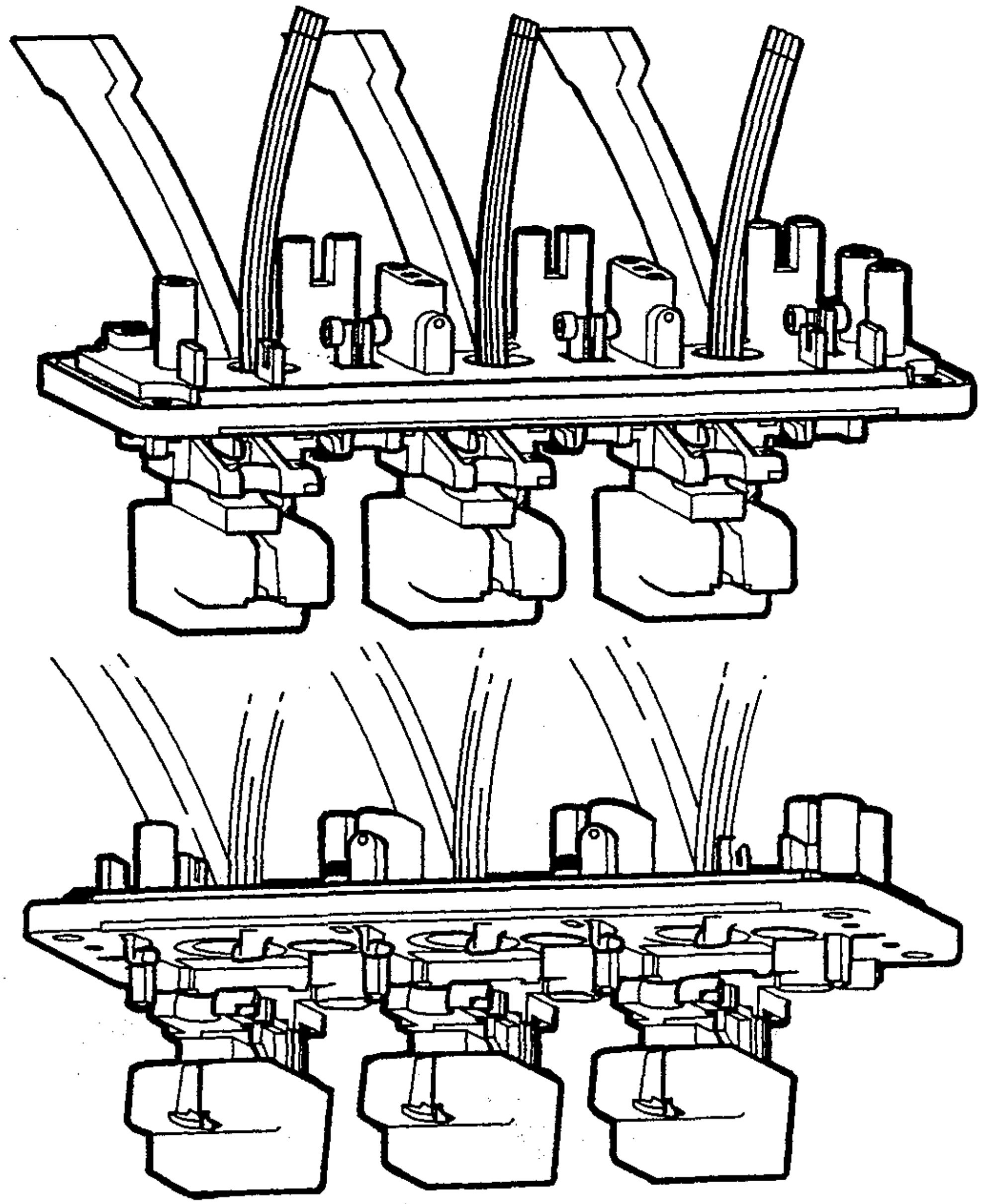


Figure 7-70. Die Cast Chassis with Sleeve Bearings (Model 2863)



(b) Using a lint-free swab, apply a very thin film of Magnalube-G Teflon grease to the shaft (Figure 7-71).

(c) Orient the shaft so that the V-slot faces the rear of the instrument (Figure 7-72). Note that the V-slot engages the locking set screws of the pump latch assembly.

(d) Insert the shaft into place in the chassis.

(e)Install the drive module (Section 7.3.5) to hold the shaft in place.

(f)Install the bearing clip to retain the pump shaft bearings (Figure 7-73).

Figure 7-71. Pump Shaft Lubrication

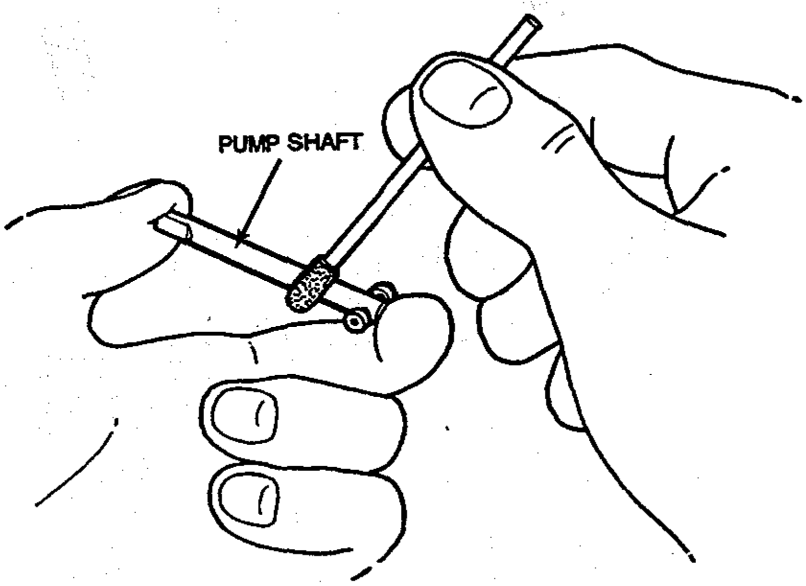
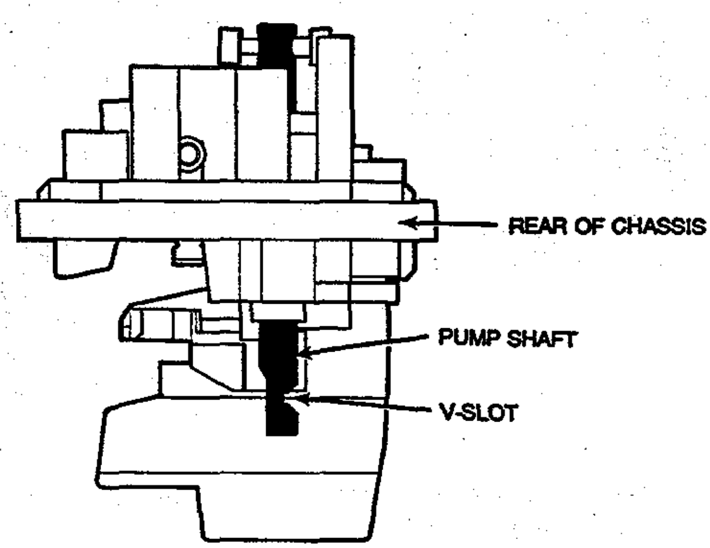


Figure 7-72. Pump Shaft V-slot Orientation



2. Die cast chassis without sleeve bearing
   (a) The die cast chassis have an undercut in the pump shaft hole to hold a reservoir of lubricant.
   (b) Place a finger over one end of the pump shaft hole in the chassis (Figure 7-74). Fill the hole with Magnalube-G Teflon grease.

Figure 7-73. Bearing Clip Installation

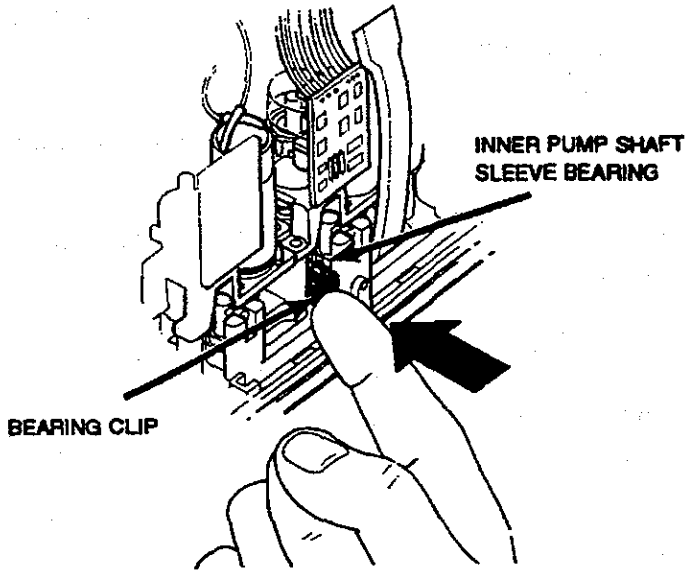
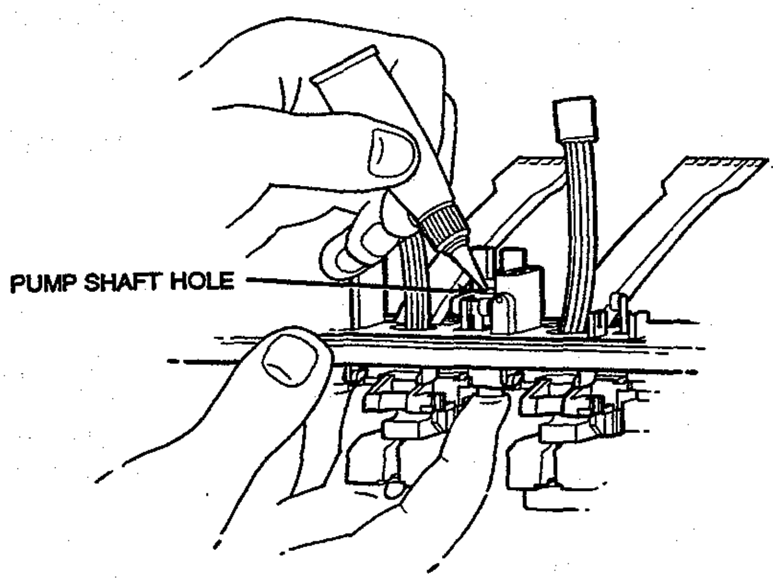


Figure 7-74. Pump Shaft Hole Lubrication (Diecast Chassis without Sleeve Bearing)



(c) Orient the shaft such that the V-slot faces the rear of the instrument (Figure 7-72). Note that the V-slot engages the locking set screws of the pump latch assembly.

(d) Insert the shaft into place in the chassis.

(e) Remove all excess grease that is squeezed from the hole.

NOTE: *Excess grease can pick up dirt, contaminate the optomodule, or interfere with the pump latch operation.*

(f) Install the drive module (Section 7.3.5) to hold the shaft in place.

f. Verify the valve actuator heights.
   1. Verify that the valve actuator heights are within specifications, using the procedure described in Section 7.3.6.

g. Adjust the pump latch height.
   1. Adjust the pump latch height, using the procedure described in Section 7.3.2.

Reassembly

a. Reassembly must be completed in the following order.
   1. Pole clamp assembly (Section 7.2.1).
   2. MEA (Section 7.5.6).
   3. Power supply PCBA (Section 7.5.5).
   4. Display module (Section 7.5.2).
   5. Main housing assembly (Section 7.1.3).
   6. Battery pack (Section 7.1.2).
   7. Lower housing assembly (Section 7.1.1).

b. Recalibrate.
   1. All sensor systems must be recalibrated (Chapter 5).

c. Test.
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

d. Restore the settings.
   1. Customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.3.8 Valve Actuator Assembly Repair

> **WARNING**
>
> *Whenever the drive module is removed and reinstalled, the valve actuator and pump latch height must be verified and, if necessary, adjusted. This is a critical step and must be performed to ensure safety as well as proper functioning of the instrument.*

Tools required:

- #1 Phillips screwdriver
- 5/16-inch flat blade screwdriver
- Guide/seal socket and 1/4-inch driver
- Lint-free swabs
- Magnalube-G Teflon grease
- Chassis stand
- 3/32-inch hex driver
- Gauge block kit
- 0.050-inch hex driver
- 0.050-inch Allen key
- 5 in. lbf torque driver

- 5/64-inch ball-end hex driver or T-6 Torx driver
- Loctite® Assure 425 surface curing threadlocker

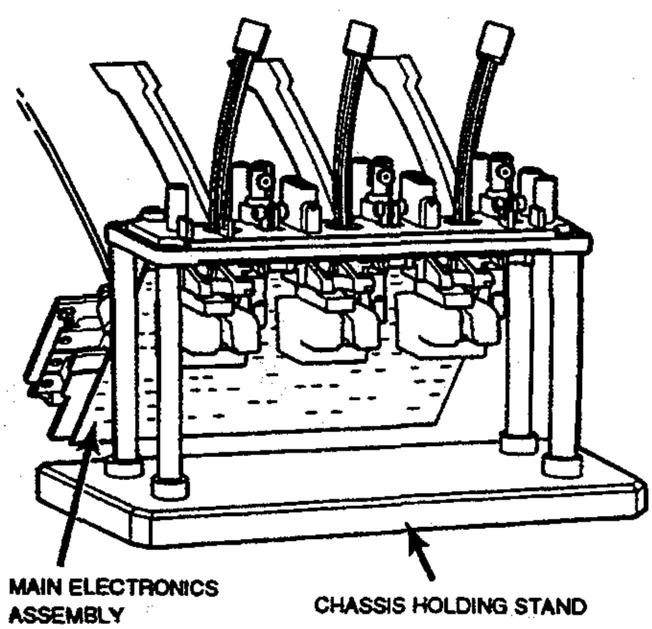
Disassembly

a. First remove:
   1. Lower housing assembly (Section 7.1.1).
   2. Battery pack (Section 7.1.2).
   3. Main housing assembly (Section 7.1.3).
   4. Display module (Section 7.5.2).
   5. Pump latch assembly (Section 7.3.1).
   6. Ground wire from chassis (Section 7.5.5).
   7. Backup battery from the locking two-pin connector (Section 7.5.3).
   8. All motor, encoder, and pressure transducer connections from MEA (Section 7.4.2).
   9. Drive module assembly (Section 7.3.5).
   10. Pole clamp assembly (Section 7.2.1).
   11. Chassis mounts (Section 7.3.9).

b. Assemble the chassis holding stand (Section 7.1).

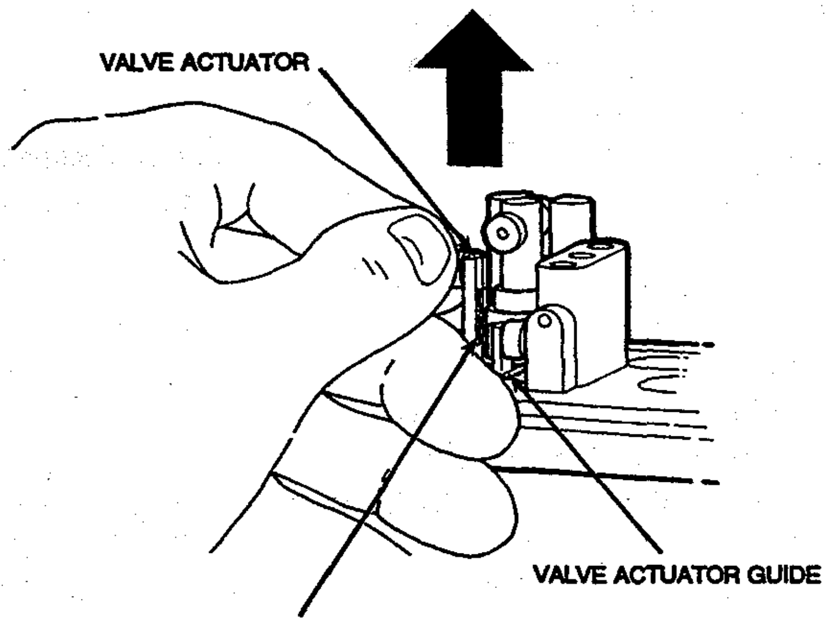
c. Remove the valve seal and guide.
   1. Carefully lift the MEA, which has the power supply PCBA attached to it, from the chassis guides.
   2. Mount the chassis on the chassis holding stand with the interior surface facing up (Figure 7-75).

Figure 7-75. Chassis Attachment to Holding Stand



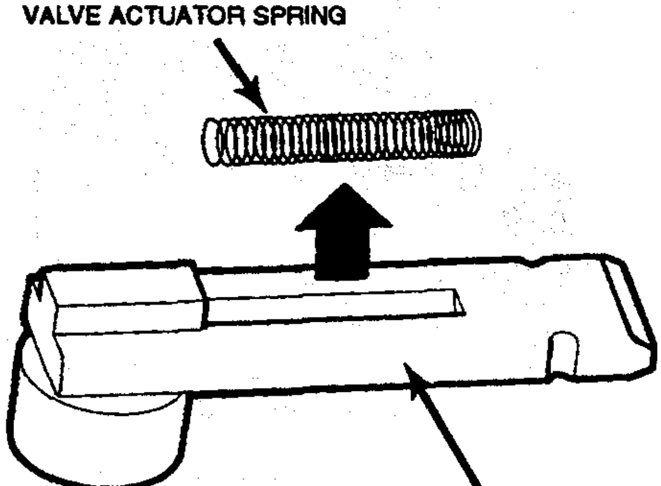
3. Position the MEA, which has the power supply PCBA attached, away from the chassis holding stand so that it allows for correct placement of the chassis (Figure 7-75).
4. Lift the valve actuators out of the guide (Figure 7-76). Some resistance may be felt as the actuators are pulled from the ring seal.

Figure 7-76. Valve Actuator Removal



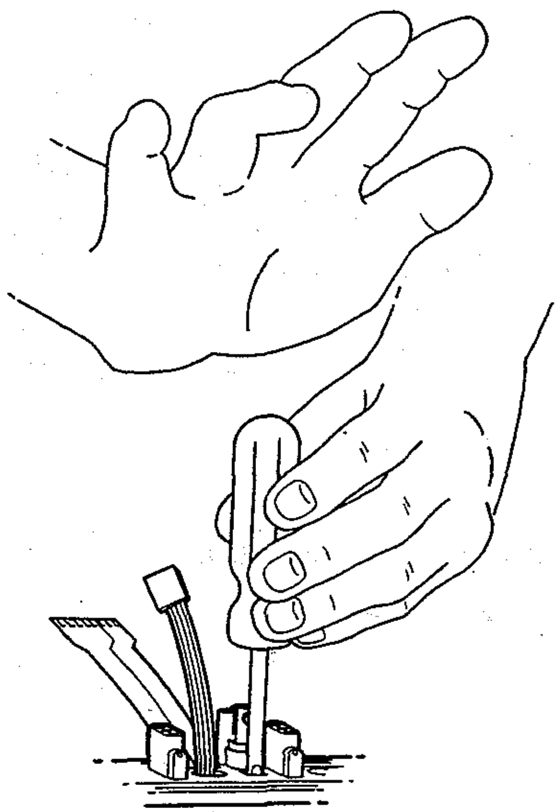
5. Remove the actuator springs located in a recess on the side of the actuator opposite the bearing (Figure 7-77).

Figure 7-77. Actuator Spring Removal



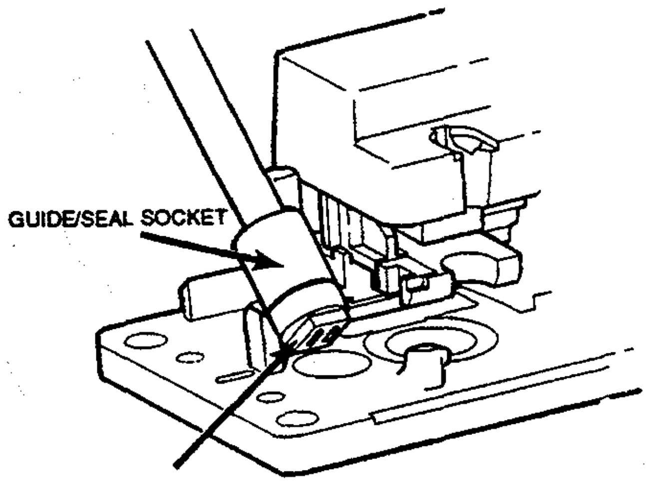
6. Place the square end of the 1/4-inch driver over the guide. Sharply tap the driver handle to remove seal and guide (Figure 7-78).

Figure 7-78. Valve Guide and Ring Seal Removal



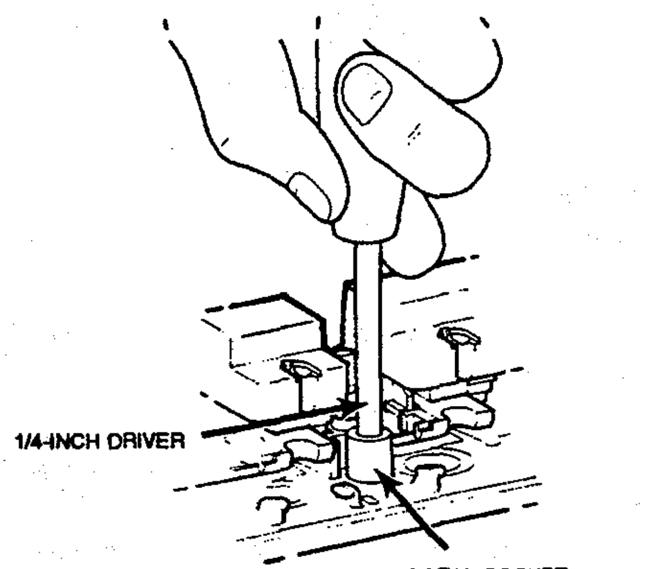
d. Inspect for the following.
   1. Damaged or torn ring seals.
   2. Damaged valve actuators.
   3. Actuator bearings that rotate smoothly without excessive play.
   4. Dirty, bent, or damaged springs.
e. Install the guide and ring seal.
   1. Orient the chassis on the stand so that the inner surface is pointing down (Figure 7-75).
   2. Position the MEA, which has the power supply PCBA attached, away from the chassis stand so that it allows for correct placement of the chassis (Figure 7-75).
   3. Seat the round end of the valve guide on the guide/seal socket (Figure 7-79).
   4. Orient the slots in the valve guide perpendicular to the front panel of the instrument.

Figure 7-79. Valve Guide Orientation



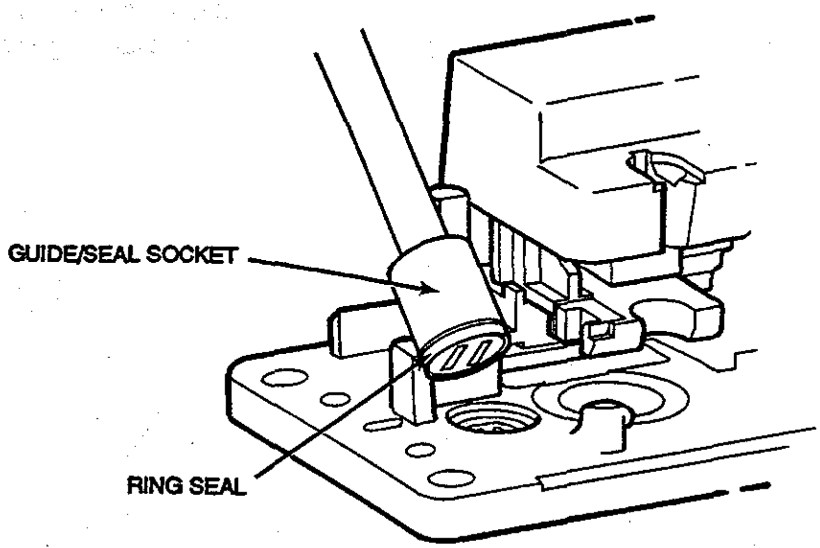
5. Firmly press the valve guide into the chassis (Figure 7-80).

Figure 7-80. Valve Guide Insertion



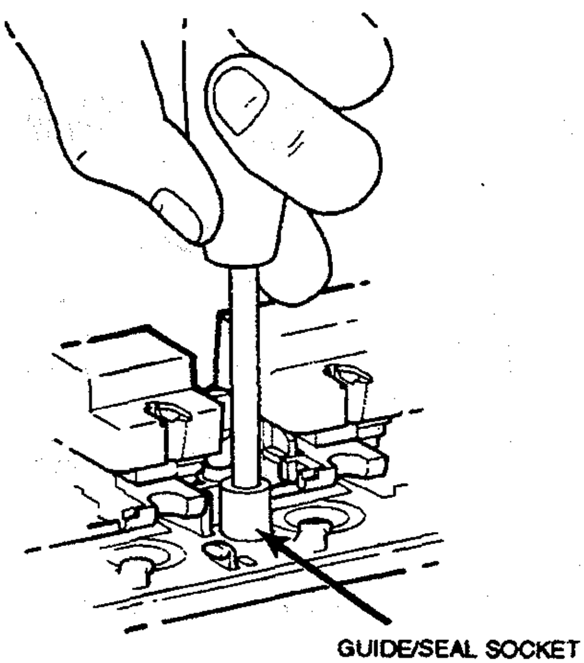
6. Seat the ring seal on the guide/seal socket with the flush side facing out (Figure 7-81).
7. Align the two socket blades with the two slots in the valve guide.

Figure 7-81. Ring Seal Orientation



8. Hold the tool perpendicular to the surface of the chassis (Figure 7-82).Using firm and even pressure, push the ring seal into the chassis recess, locking the guide in place.
9. Ensure that the ring seal is flush with the chassis.

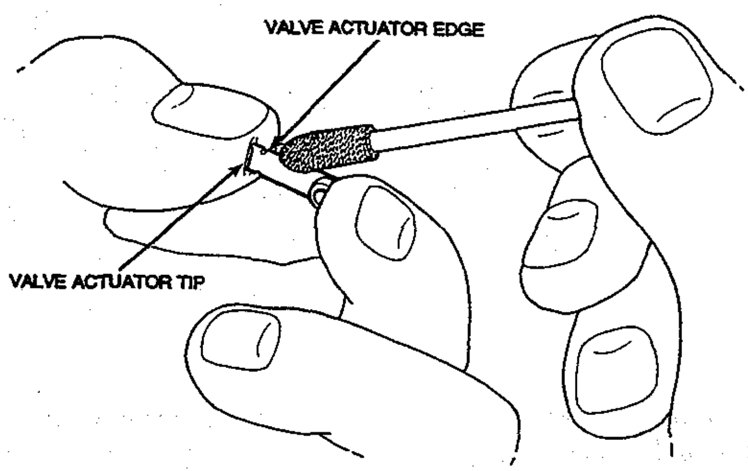
Figure 7-82. Ring Seal Insertion



f. Lubricate and install valve actuators:

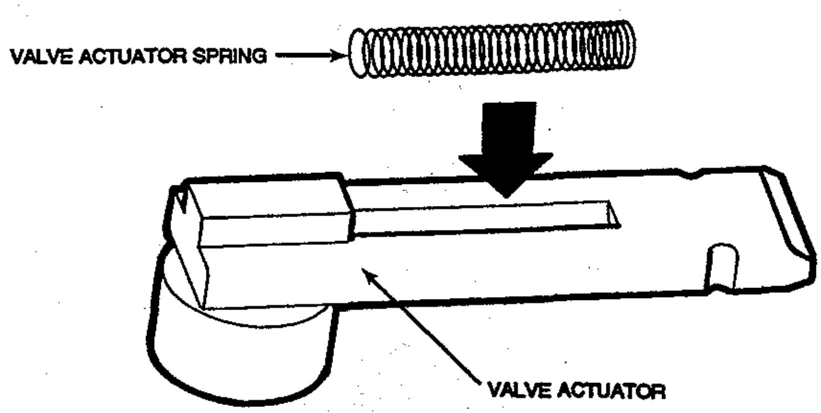
1. With a lint-free swab, apply a thin film of Magnalube-G Teflon grease to each edge of the valve actuator (Figure 7-83). Ensure that no grease gets on actuator tip.

Figure 7-83. Valve Actuator Lubrication



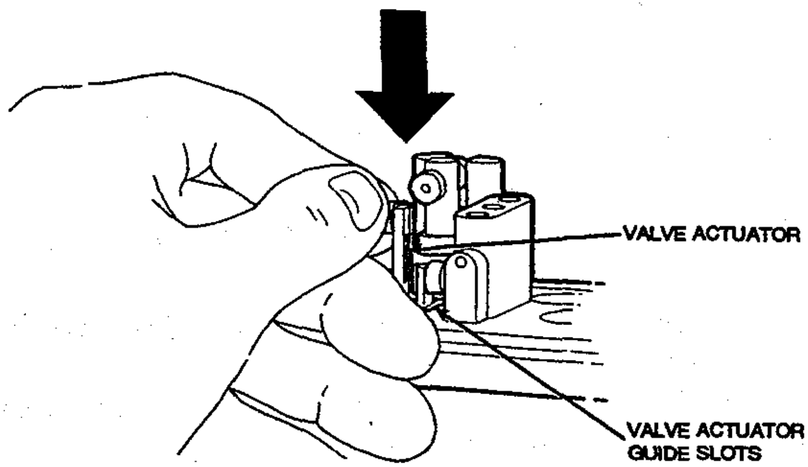
2. Insert the springs into the recess in the side of the valve actuators (Figure 7-84).

Figure 7-84. Spring Insertion into Valve Actuator Recess



3. Insert the actuators into the valve guide slots from the interior side of the chassis (Figure 7-85).
4. Orient the actuators such that the bearings are facing away from each other.

Figure 7-85. Valve Actuator Insertion into Guide Slots



g. Install the drive module assembly (Section 7.3.5).

h. Verify the valve actuator heights.

   1. Verify that the valve actuator heights are within specifications, using the procedure described in Section 7.3.6.

i. Install the pump latch assembly.

   1. Install the pump latch assembly, using the procedure described in Section 7.3.1.

j. Adjust the pump latch height.

   1. Adjust the pump latch height, using the procedure described in Section 7.3.2.

k. Perform run-in.

CAUTION

Use extreme care to ensure that the springs are not distorted during insertion. DO NOT apply any substance, such as grease, to hold the springs in place.

   1. Press the actuators in completely.
   2. Ensure that the actuators move freely and spring up.
   3. Apply 13V power to the motor (positive to the red lead), and operate for 24 hours.

Reassembly

a. Reassemble in the following order.

   1. Chassis mounts (Section 7.3.8).
   2. Pole clamp assembly (Section 7.2.1).
   3. MEA (Section 7.5.6).
   4. Backup battery to locking two-pin connector (Section 7.5.3).

5. Ground wire to chassis (Section 7.5.5)
6. Display module (Section 7.5.2).
7. Main housing assembly (Section 7.1.3).
8. Battery pack (Section 7.1.2)
9. Lower housing assembly (Section 7.1.1).

b. Recalibrate.

1. All sensor systems must be recalibrated (Chapter 5).

c. Test.

1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.
2. Use negative head heights when performing the volume accuracy test to ensure proper operation of the valve actuator assembly.

d. Restore the settings.

1. Customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.3.9 Repair or Replacement of Chassis Mounts

Tools required:

- #1 Phillips screwdriver
- Ball plunger adjustment tool

Disassembly

a. First, remove the following.

1. Lower housing assembly (Section 7.1.1).
2. Pole clamp assembly (Section 7.2.1).

b. Remove the chassis mounts.

1. Remove the two Phillips panhead screws on each mount (Figure 7-86).

Figure 7-86. Chassis Mount Removal

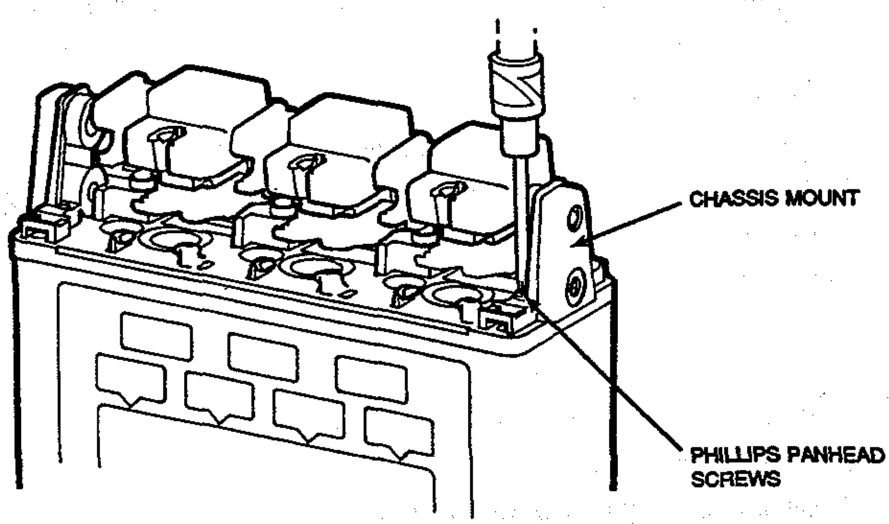
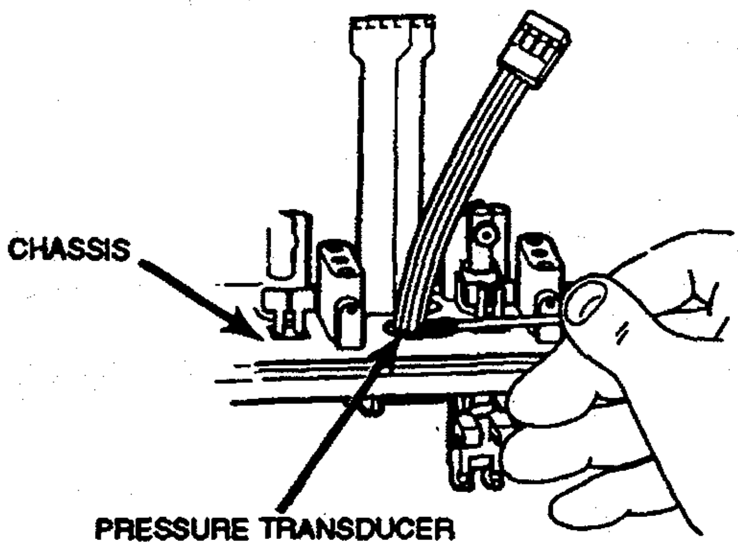
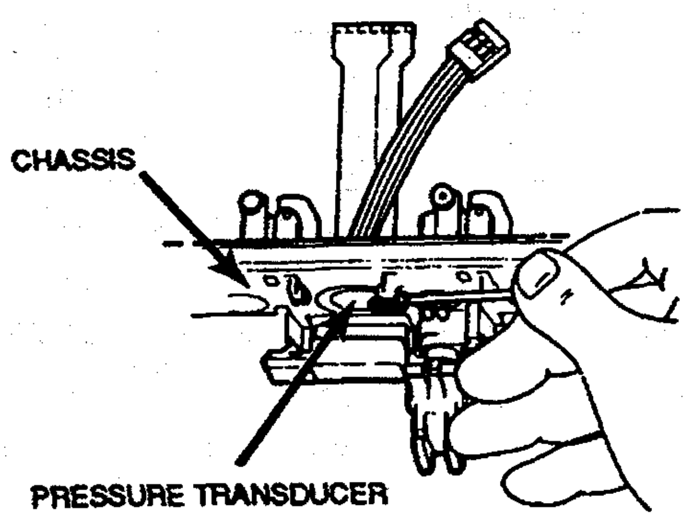


Figure 7-103. Isopropyl Alcohol Application to Pressure Transducer



A. APPLICATION ABOVE PRESSURE TRANSDUCER.



B. APPLICATION BELOW PRESSURE TRANSDUCER.

NOTE: *The Model 2863 connectors will appear differently.*

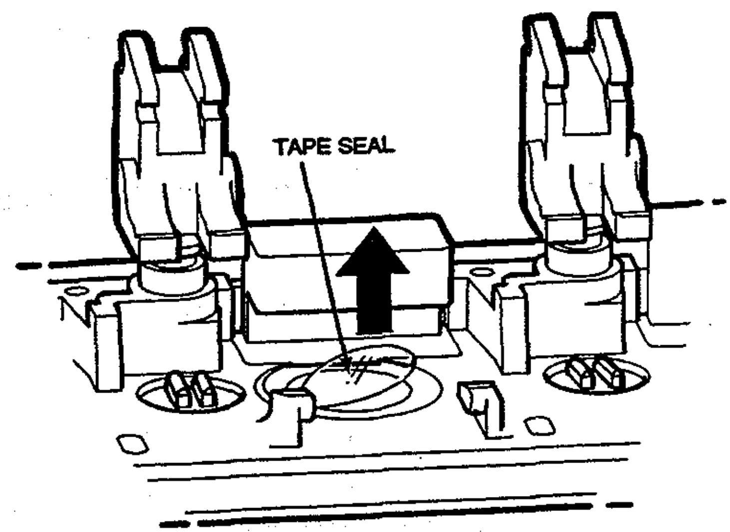
   11. Pole clamp assembly (Section 7.2.1).
   12. Chassis mounts (Section 7.3.9).

b. Assemble the chassis holding stand (Section 7.1).

c. Remove the pressure transducer.

   1. Carefully lift the MEA, which has the power supply PCBA attached to it, from the chassis guides.
   2. Mount the chassis on the chassis holding stand with the interior surface facing up (Figure 7-75).
   3. Position the MEA, which has the power supply PCBA attached away from the chassis holding stand so that it allows for correct placement of the chassis (Figure 7-75).
   4. Remove the tape seal covering the pressure transducer (Figure 7-102).

Figure 7-102. Tape Seal Removal



   5. With a cotton swab, apply isopropyl alcohol to both sides of the seam between the chassis and transducer. Let the alcohol soak into the seam for about 30 seconds (Figure 7-103).
   6. Using a blunt instrument, press the transducer from the inside of the chassis (Figure 7-104).

   NOTE: *A pressure transducer must not be reused.*

Reassembly

a. Prepare the surface.

   1. Reverse the position of the chassis by placing the chassis in the chassis holding stand with the motors facing down (Figure 7-63).
   2. Apply isopropyl alcohol to any residue remaining in the transducer hole.

b. Recalibrate.

1. All sensor systems must be recalibrated (Chapter 5).

c. Test.

1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

d. Restore the settings.

1. Customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.4.3 Pressure Transducer Replacement

WARNING

Whenever the drive module is removed and reinstalled, the valve actuator and pump latch height must be verified and, if necessary, adjusted. This is a critical step and must be performed to ensure safety, as well as proper functioning of the instrument.

Tools required:

- #1 Phillips screwdriver
- 5/16-inch flat blade screwdriver
- 3/32-inch hex driver
- Magnalube-G Teflon grease
- Chassis stand
- Gauge block assembly kit
- Loctite® Assure 425 surface curing threadlocker
- Nonmetallic scraper
- Lint-free swabs
- Isopropyl alcohol
- Loctite® primer "N"
- Loctite® 518 gasket eliminator

Disassembly

a. First, remove the following.

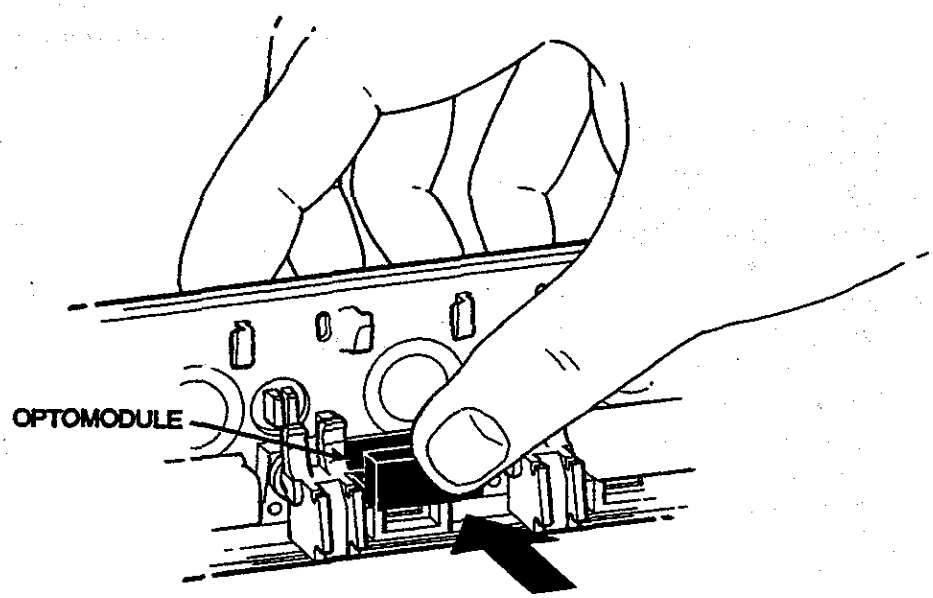
1. Lower housing assembly (Section 7.1.1).
2. Battery pack (Section 7.1.2)
3. Main housing assembly (Section 7.1.3)
4. Display module (Section 7.5.2)
5. Pump latch movable jaw (Section 7.3.3).
6. Air-in-line sensor (Section 7.4.1).
7. Ground wire from chassis (Section 7.5.5).
8. Backup battery from the locking two-pin connector (Section 7.5.3).
9. All motor, encoder, and pressure transducer connections from MEA (Section 7.4.2).
10. Drive module assembly (Section 7.3.5).

d. Inspect for the following.
   1. Damaged optomodule seals.
   2. Dirty or damaged sensor lenses.
   3. Damaged flex.
   4. Properly aligned and spaced flex contacts.
   5. Slide link reflector damage.

Reassembly

a. Reassemble in the following order.
   1. Seat the optomodule into the chassis so that the base is flush with the chassis surface (Figure 7-101).
   2. Insert the flex into the connector and lock.

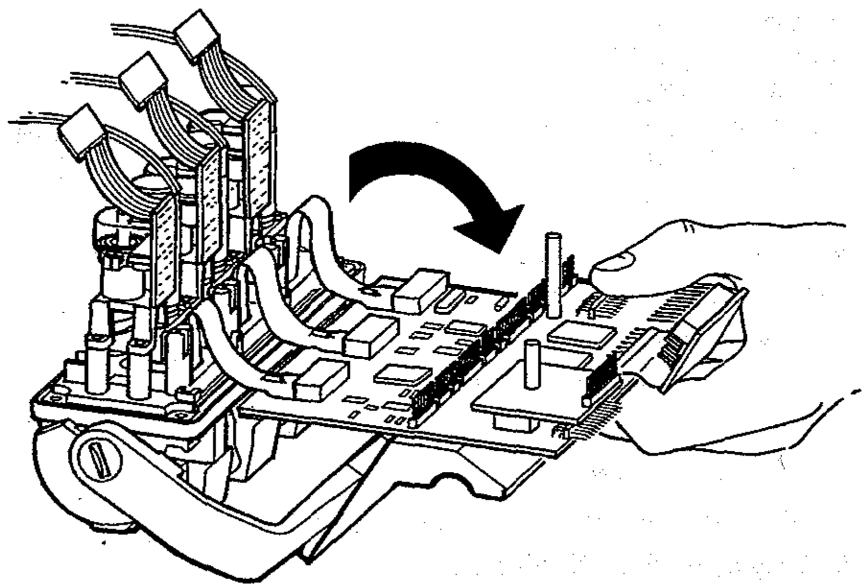
Figure 7-101. Optomodule Installation



   3. Reassemble the remaining components in the following order.
      (a) Air-in-line sensor module (Section 7.4.1).
      (b) Power supply PCBA (Section 7.5.5).
      (c) Display module (Section 7.5.2).
      (d) Main housing assembly (Section 7.1.3).
      (e) Battery pack (Section 7.1.2).
      (f) Pump latch movable jaw (Section 7.3.2).
      (g) Lower housing assembly (Section 7.1.1).

2. Carefully lay the MEA down on a table. Unlock the flex connector and remove the flex (Figure 7-99).

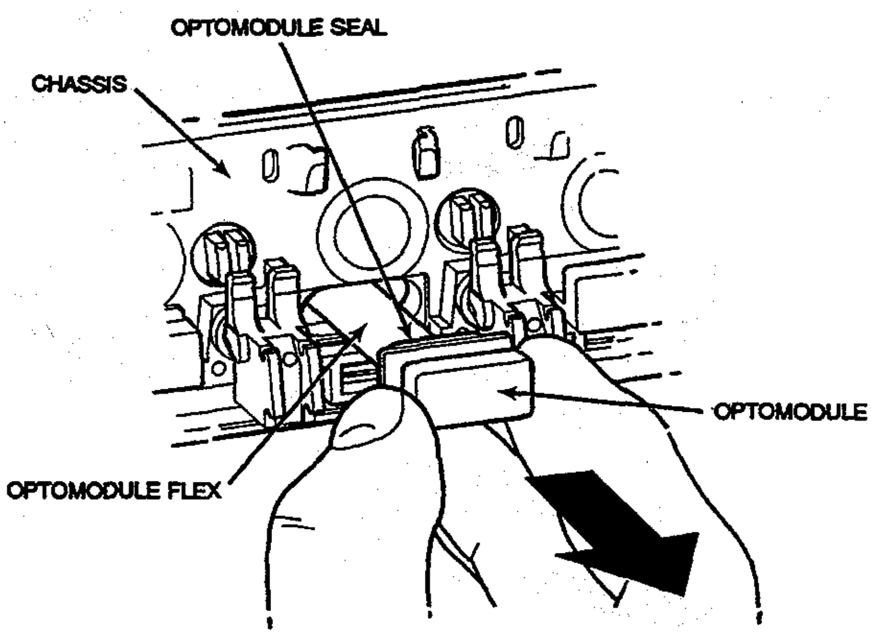
Figure 7-99. Optomodule Flex Disconnection



c. Remove the optomodule.

1. Remove the optomodule from the chassis, using care to guide the flex cable through the slot (Figure 7-100).

Figure 7-100. Optomodule Removal



7.4.2 Optomodule Repair or Replacement

Tools required:

- #1 Phillips screwdriver
- 3/32-inch hex driver
- Small flat blade screwdriver
- Tweezers
- 5/64-inch ball-end driver or T-6 Torx driver
- 3-in. lbf torque driver
- (For Model 2860 only) X-ACTO knife
- (For Model 2860 only) 0.50-inch length of 0.25-inch-diameter heat-shrink tubing (must be UL 224 and CSA 198 approved, e.g., Alpha FIT-221)
- Needle nose pliers

Disassembly

a. First, remove the following.
   1. Lower housing assembly (Section 7.1.1).
   2. Pump latch movable jaw (Section 7.3.3).
   3. Battery pack (Section 7.1.2).
   4. Main housing assembly (Section 7.1.3).
   5. Air-in-line sensor (Section 7.4.1).
   6. Display module (Section 7.5.2).
   7. Power supply PCBA (Section 7.5.5).

b. Disconnect the optomodule flex.
   1. Using needle-nose pliers, disconnect the motor from the MEA, pressure transducer, and encoder for all three channels (Figure 7-98). DO NOT pull on the wires. Note the orientation of the connectors.

Figure 7-98. Motor, Pressure Transducer, and Encoder Disconnection

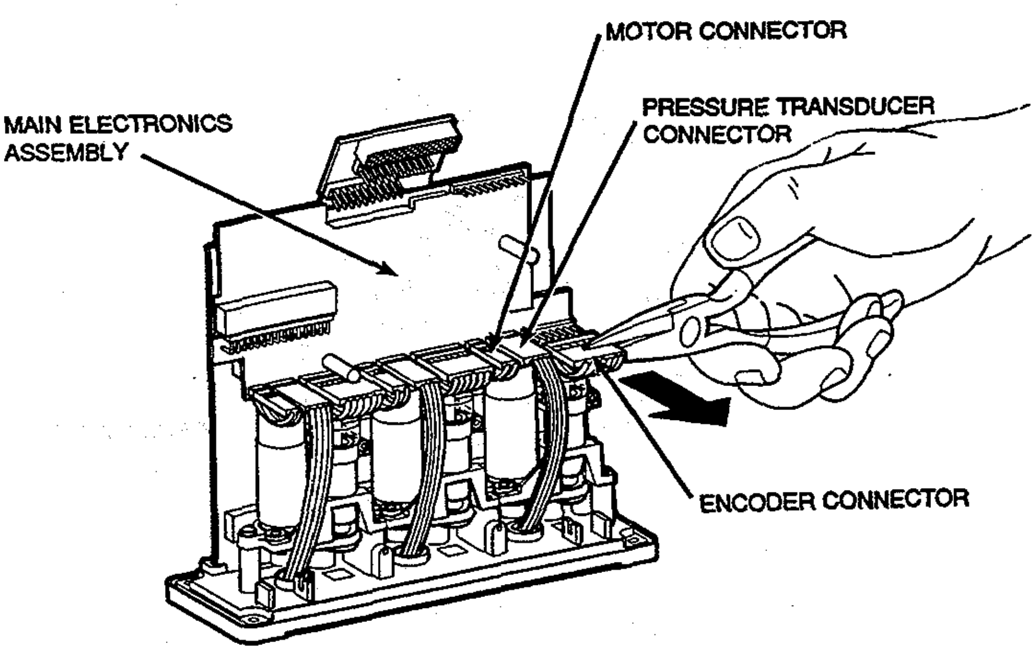
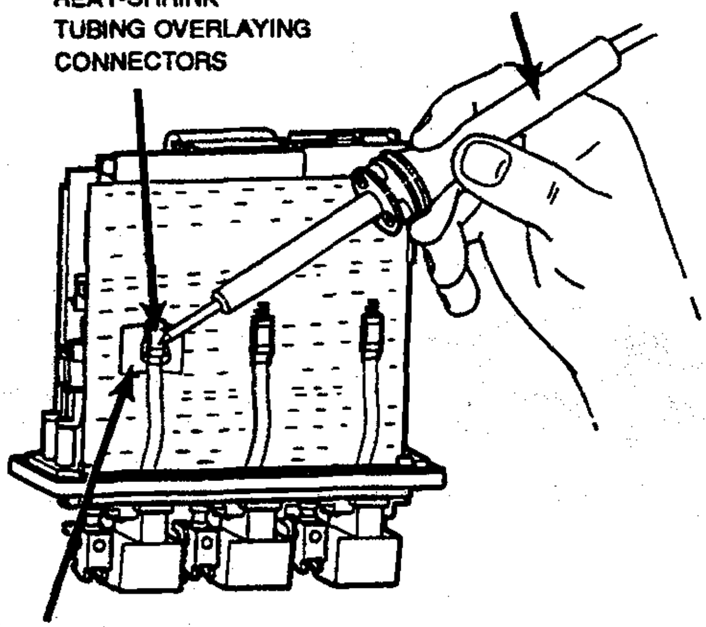


Figure 7-97. Heat-shrink Tubing Application



NOTE: *The Model 2863 connectors and board will appear differently.*

6. (For Model 2860 only) Mate the heat-shrink tubing over both connectors.
7. Ensure complete coverage. Use a thin heat deflector under the connector to prevent thermal damage. Apply heat.
8. (For Model 2863 only) Connect the ultrasensor tail flexes to the main board assembly. Fold the ultrasensor tail flexes so that the outside loop is down and against the circuit board. Apply a 1-1/2" ± 1/4" of 1/4" Kapton tape on the folded area.
9. The remaining components are to be reassembled in the following order.
   - Main housing assembly (Section 7.1.3).
   - Battery pack (Section 7.1.2).
   - Pump latch movable jaw (Section 7.3.3).
   - Lower housing assembly (Section 7.1.1).

b. Recalibrate.

1. All sensor systems must be recalibrated (Chapter 5).

c. Test.

1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

d. Restore the settings.

1. Customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

Figure 7-95. ***Air-in-line Sensor Module Seal***

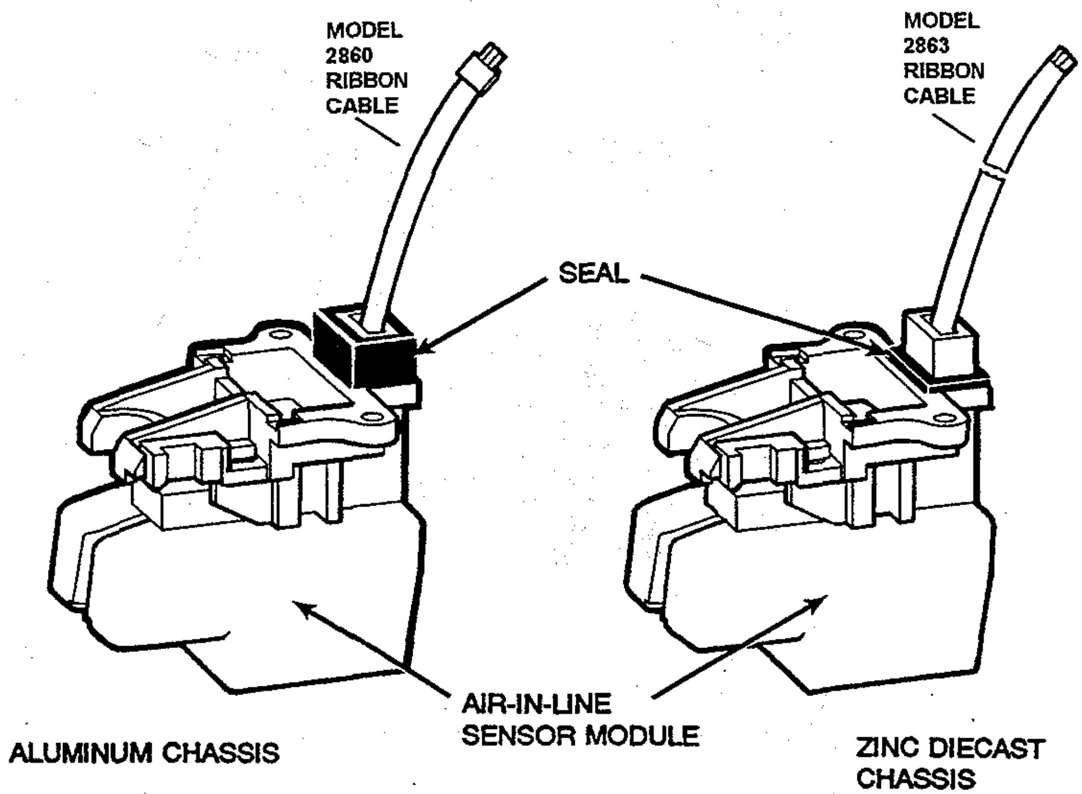
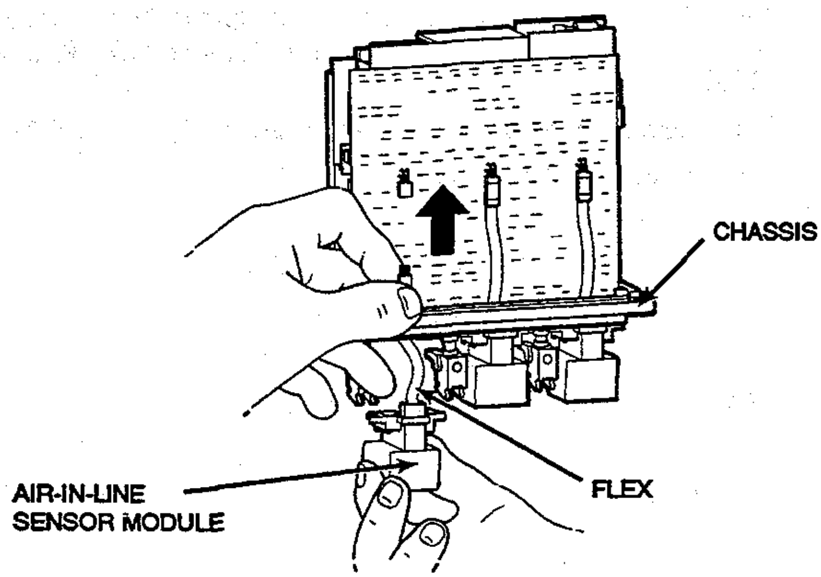


Figure 7-96. ***Air-in-line Sensor Module Reassembly***



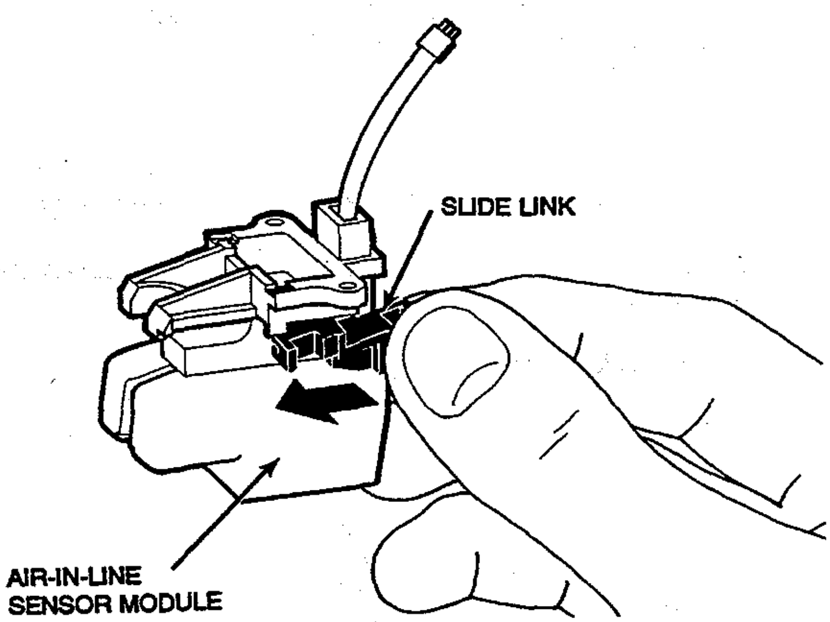
NOTE: *The Model 2863 connectors and board will appear differently.*

f. Inspect for the following.
   1. Cracked or damaged sensor housing.
   2. Dirty sensor tubing slot; clean, if necessary.
   3. Damaged seal.
   4. Damaged flex or connector.
   5. Damaged slide link reflector.

Reassembly

a. Reassemble in the following order.
   1. Install the slide link on the sensor module guide (Figure 7-94).

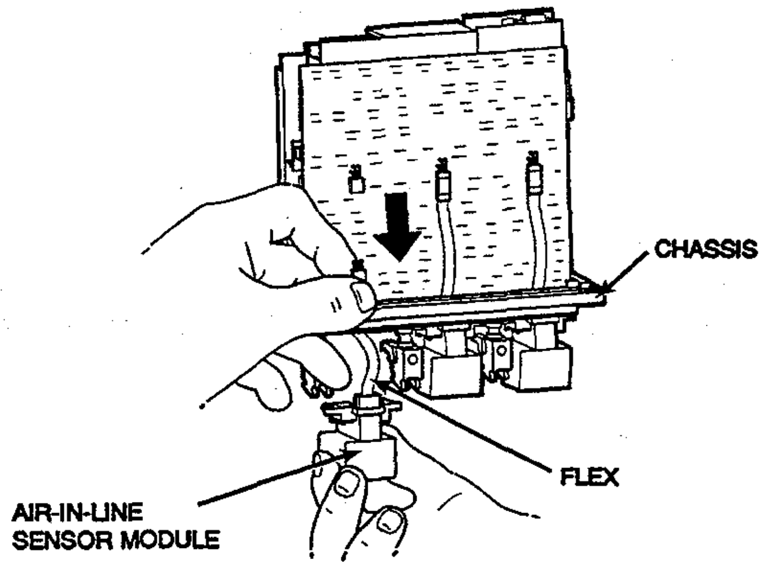
Figure 7-94. Slide Link Installation



NOTE: *The Model 2863 connector will appear differently.*

   2. Ensure that the proper seal is attached to the sensor module (Figure 7-95). Refer to the illustrated parts list in Appendix E.
   3. Feed the flex through the slot in the chassis (Figure 7-96).
   4. Install screws and tighten to 3 in. lbf torque.
   5. (For Model 2860 only) Slide a 0.50-inch-long piece of 0.25-inch-diameter UL-approved heat-shrink tubing over the sensor flex (Figure 7-97).

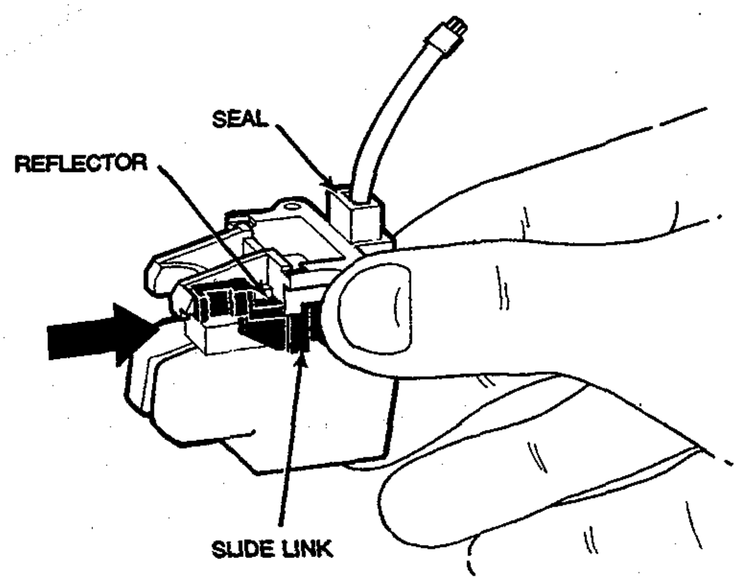
Figure 7-92. Air-in-line Sensor Module Removal



NOTE: *The Model 2863 connectors and board will appear differently.*

3. Remove and save the slide link, being careful not to touch the reflector Figure 7-93).

Figure 7-93. Slide Link Reflector



NOTE: *The Model 2863 connector will appear differently.*

Figure 7-90. Air-in-line Sensor Mounting Screws

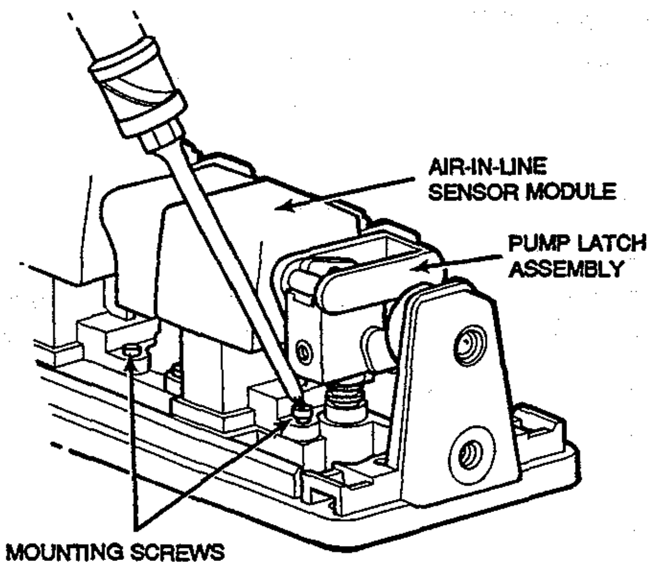
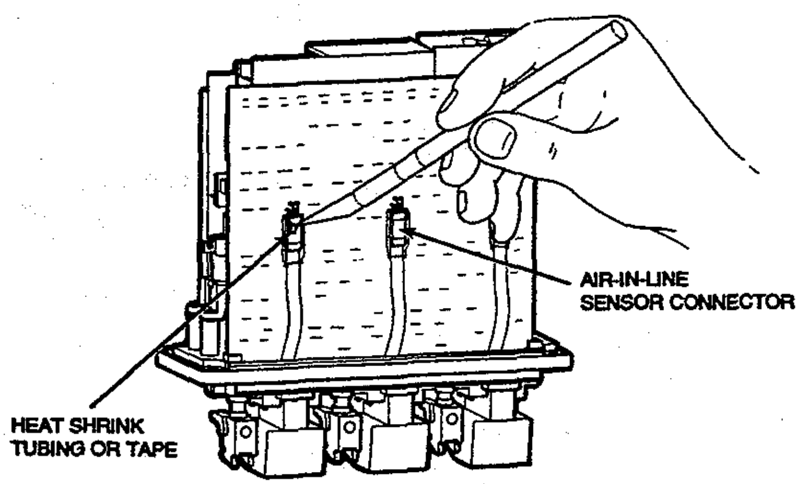


Figure 7-91. Heat Shrink Tubing or Tape Removal



NOTE: *The Model 2863 connectors and board will appear differently.*

- (For Model 2860 only) 0.5-inch length of 0.25-inch-diameter heat-shrink tubing (must be UL 224 or CSA 198 approved, e.g., Alpha FIT-221).

Disassembly

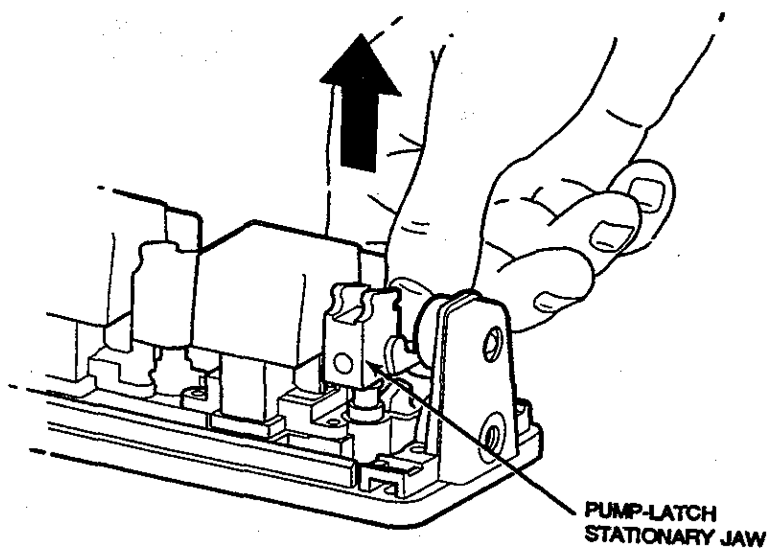
a. First, remove the following.

   1. Lower housing assembly (Section 7.1.1).
   2. Pump latch movable jaw (Section 7.3.3).
   3. Battery pack (Section 7.1.2).
   4. Main housing assembly (Section 7.1.3).

b. Loosen the air-in-line sensor.

c. Lift the pump latch stationary jaw so that it is at the top of the stroke (i.e., stationary jaw is in the farthest position from the chassis). (See Figure 7-89.)

Figure 7-89. Pump Latch Stationary Jaw in Farthest Position above Chassis

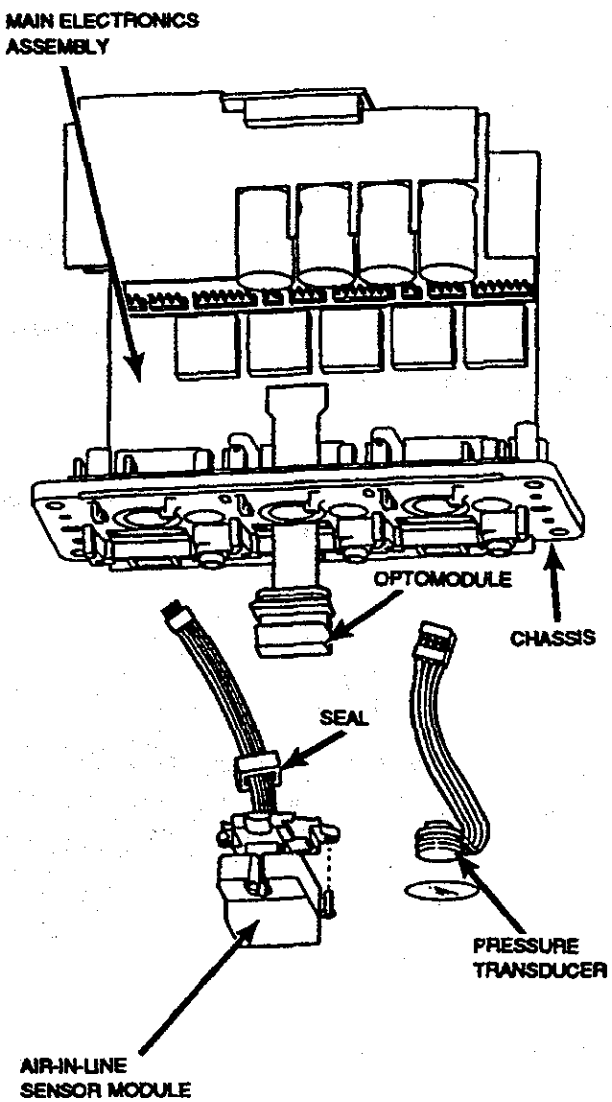


d. Loosen the air-in-line sensor mounting screws with a 7/64-inch ball-end hex driver or T-6 Torx driver (Figure 7-90).

e. Remove the sensor.

   1. (For Model 2860 only) Remove the heat-shrink tubing or tape that secures the sensor connector to the back of the MEA (Figure 7-91).
   2. Disconnect the sensor from the MEA, and slide the flex through the slot in the chassis (Figure 7-92).

Figure 7-88. Exploded View of Sensor Systems



NOTE: *The Model 2863 Air-in-line connector will appear differently.*

7.4.1 Air-in-line Sensor Replacement

Tools required:

- 3/32-inch hex driver
- Small flat blade screwdriver
- Tweezers
- 5/64-inch ball-end hex driver or T-6 Torx driver
- 3 in. lbf torque driver
- (For Model 2860 only) X-ACTO knife

Reassembly

a. Reinstall the chassis mounts.

1. Chassis mounts are installed in the reverse order of removal.

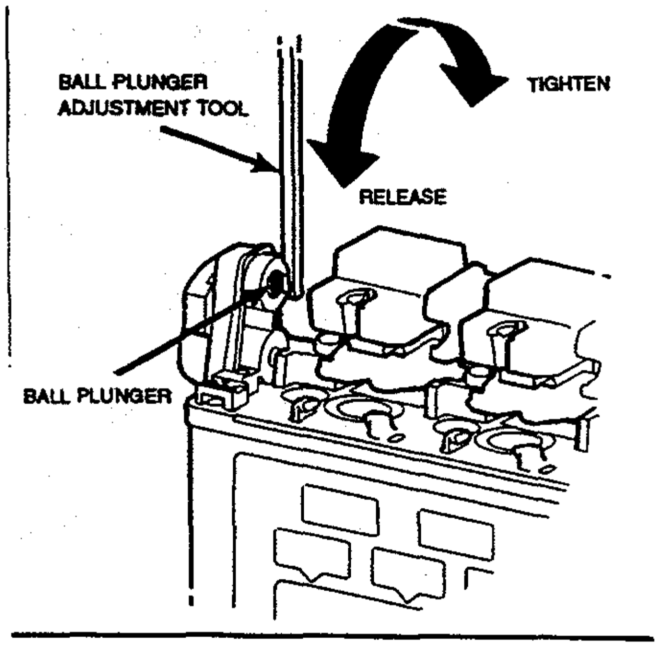
b. Reassemble in the following order.

1. Pole clamp assembly (Section 7.2.1).
2. Lower housing assembly (Section 7.1.1).

c. Ball plunger adjustment (Figure 7-87).

1. Using the ball plunger adjustment tool, turn the ball plunger clockwise until contact is made with the pole clamp assembly.
2. Adjust the ball plunger by turning counterclockwise 1/4 turn (Figure 7-87).

Figure 7-87. Ball Plunger Adjustment



7.4 Sensors

The sensors are depicted in Figure 7-88.

NOTE: *Two different types of chassis were produced. Early versions were machined from aluminum, and the later versions are die cast. The machined aluminum versions are silver colored and can be identified by the white plastic pump shaft sleeve bearings (see Figure 7-28). Die cast chassis use a shorter air-in-line sensor module seal.*

Figure 7-105. Pressure Transducer Adhesive Application

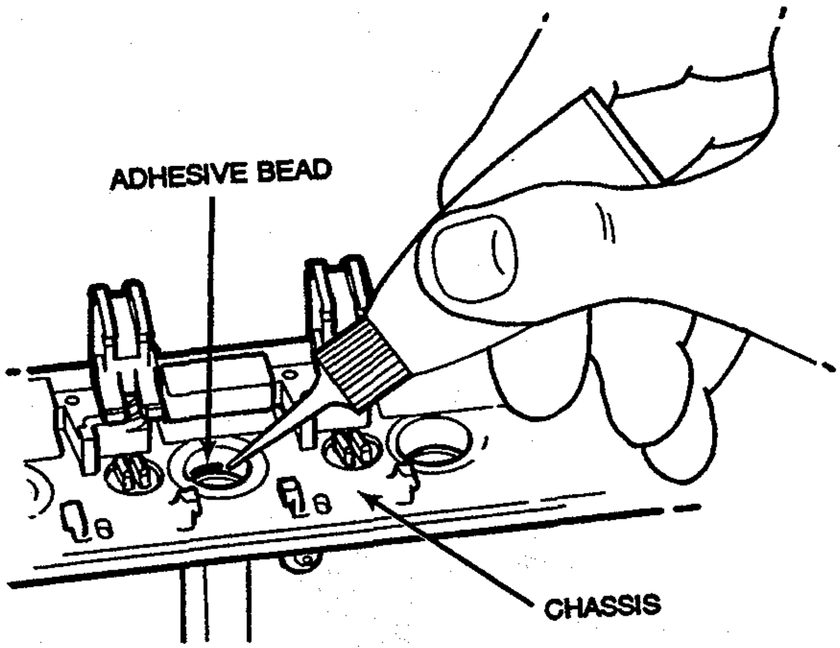
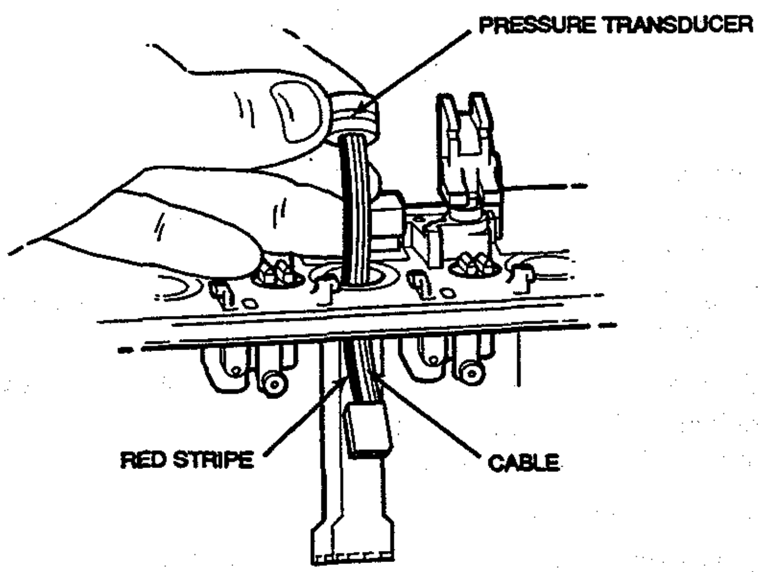


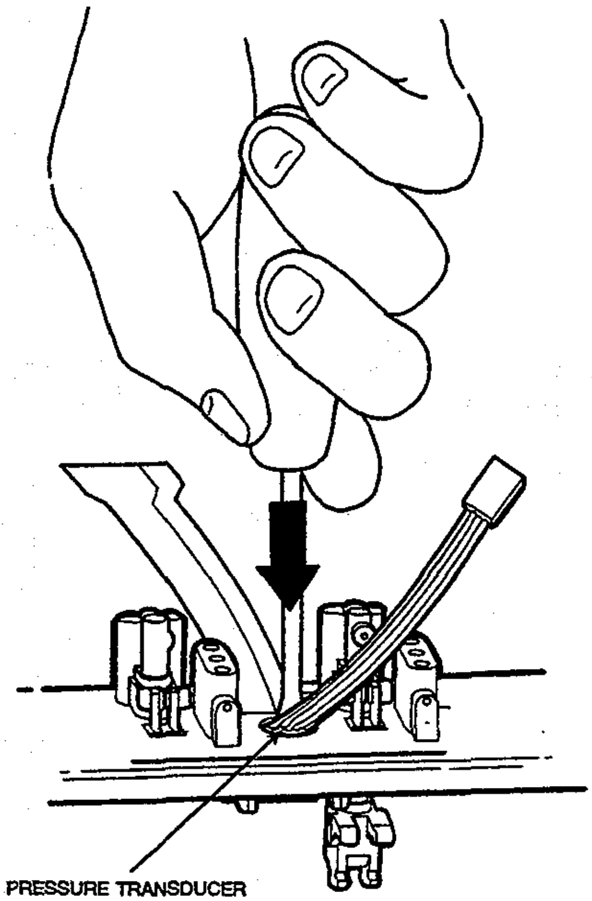
Figure 7-106. Chassis Orientation for Pressure Transducer Insertion



NOTE: *The Model 2863 connector will appear differently.*

3. Gently press along the edges of the transducer until the top surface is flush with the chassis (Figure 7-107).
4. Cure for 15 minutes.

Figure 7-104. Pressure Transducer Removal



NOTE: *The Model 2863 connector will appear differently.*

3. Using a nonmetallic instrument that will not scratch the metal surface, remove any remaining residue.
4. Using a lint-free swab, prime the transducer hole surface with Loctite primer "N". Wait 5 minutes and apply a second coat.
5. Apply one coat of Loctite primer "N" to the pressure transducer sides.
6. Let both surfaces dry for 5 minutes.

   NOTE: *Do not substitute other adhesives or primers.*

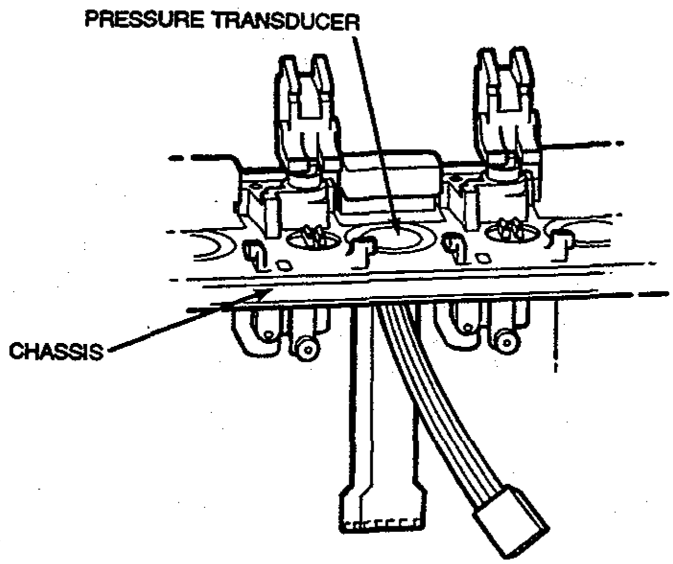
b. Install a new transducer.

1. Apply a small bead of Loctite 518 on the inner wall near the shoulder (Figure 7-105).
2. With the red stripe on the cable oriented to the left (when you are facing toward the front of the chassis, motors down, and transducer cable toward the front) insert the new transducer in the hole (Figure 7-106).

CAUTION

DO NOT press or dent the top surface of the transducer.

Figure 7-107. Pressure Transducer Insertion

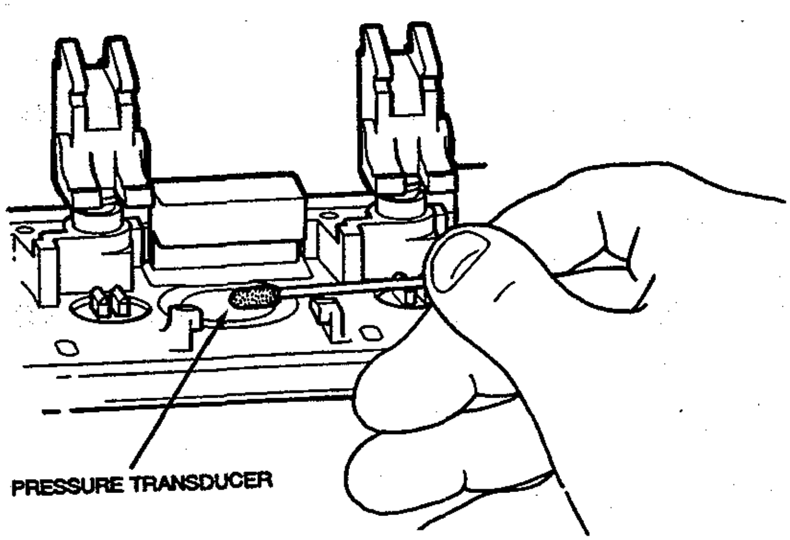


NOTE: *The Model 2863 connector will appear differently.*

c. Apply tape seal.

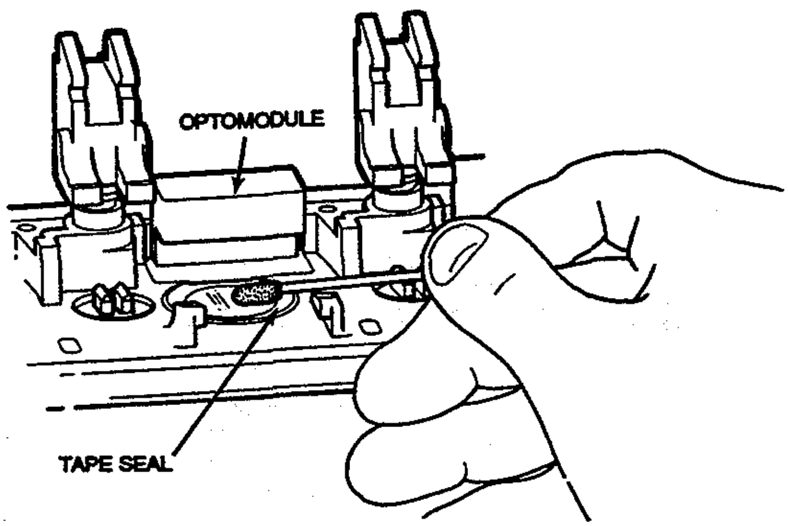
1. Gently clean the transducer surface and surrounding area with a clean swab dampened with isopropyl alcohol (Figure 7-108).

Figure 7-108. Contaminant Removal



2. Cover the transducer surface with the tape seal that is included with the new transducer (Figure 7-109).

Figure 7-109. Tape Seal Application



3. Align the flat edge of the tape with the edge of the optomodule.
4. Gently press down the tape with a dry swab.

d. Reinstall in the following order.
1. Air-in-line sensors (Section 7.4.1)
2. Pump latch movable jaw (Section 7.3.3)
3. Drive module (Section 7.3.5)

CAUTION

Verify the proper valve actuator height (Section 7.3.6 and, if needed, adjust the pump latch height at this point (Section 7.3.2).

4. Chassis mounts (Section 7.3.9).
5. Pole clamp assembly (Section 7.2.1).
6. MEA (Section 7.5.6).
7. Backup battery to locking two-pin connector (Section 7.5.3).
8. Ground wire to chassis (Section 7.5.5).
9. Display module (Section 7.5.2).
10. Main housing assembly (Section 7.1.3).
11. Battery pack (Section 7.1.2).
12. Lower housing assembly (Section 7.1.1).

e. Recalibrate.
1. All sensor systems must be recalibrated (Chapter 5).

f. Test.
1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except

for the battery.

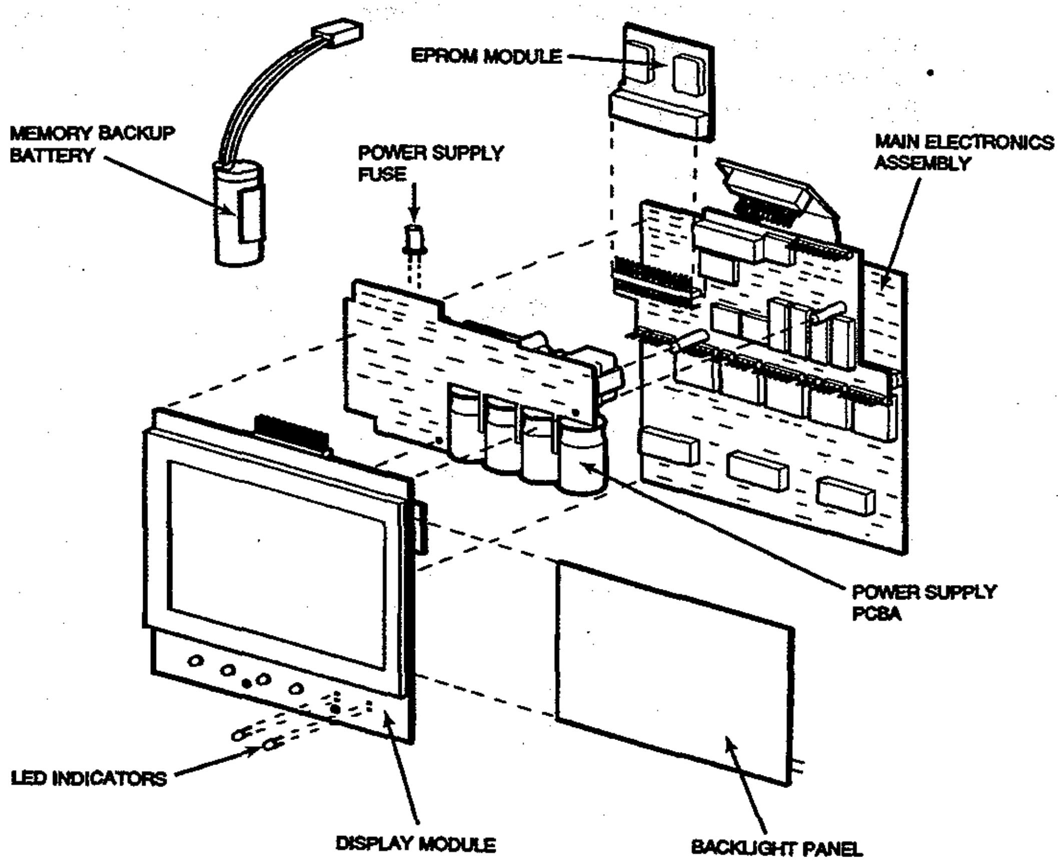
g. Restore the settings.

1. Customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.5 Electronics

An exploded view of the electronics components is shown in Figure 7-110.

Figure 7-110. Exploded View of Electrical Components (Model 2860 only)



NOTE: *In this view, the Model 2863 EPROM board is reversed and the MEA board is one piece, not two.*

7.5.1 EPROM Module

Tool required: #1 Phillips screwdriver

Removal

a. First, remove the following.

1. Battery pack (Section 7.1.2).

b. Remove the EPROM module

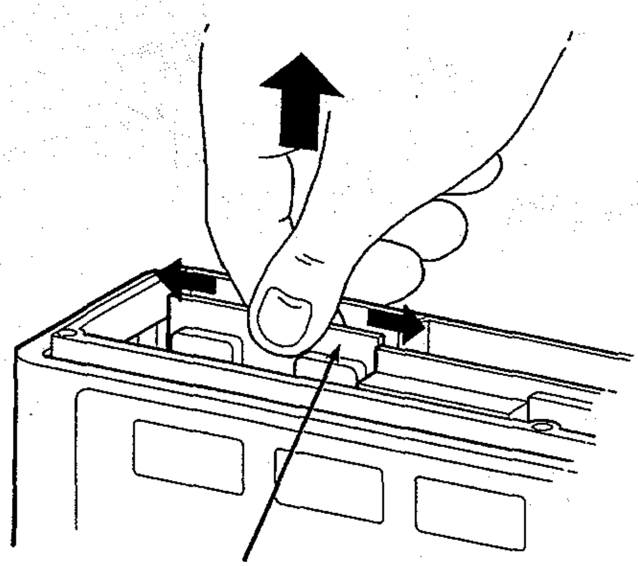
CAUTION

Static charges will damage instrument circuitry. Always wear a grounded wrist strap while disassembling the instrument or while handling EPROMs. Periodically check the grounding point and wrist strap continuity.

NOTE: *Ensure that the instrument is off before proceeding, or the instrument calibration and customized settings will be lost.*

1. Pull the EPROM module straight up (Figure 7-111). The EPROM module is mounted on a multipin connector and should not require excessive force for removal. However, a slight side-to-side movement may be required to pull it free of the connector pins.

Figure 7-111. EPROM Module Removal



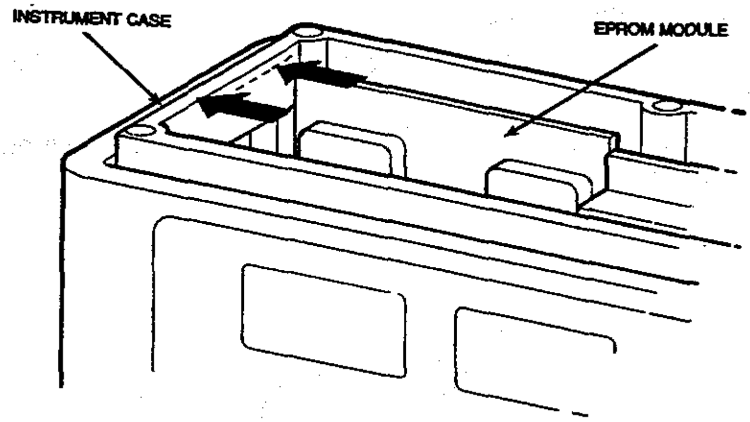
NOTE: *The Model 2863 board is reversed in this view.*

Replacement

a. Install the following.

1. Orient the module with the component side facing toward the front of the instrument for the Model 2860 and towards the rear of the instrument for the Model 2863, and insert into the multipin connector (Figure 7-112).
2. Make sure that the connector is centered and no pins protrude on either side of the module connector. Some side-to-side movement may be required to fully seat the module. When properly installed, the EPROM module will be squarely seated, and the board will be slightly lower than the flange at the top of the instrument case.

Figure 7-112. EPROM Module Insertion



NOTE: *The Model 2863 board is reversed in this view.*

3. Turn the instrument on.
4. Verify that the instrument powers up correctly.
5. Verify the software version displayed is correct.

   NOTE: *If the instrument does not power up correctly, reseat the EPROM module. Replace the module if reseating is not effective.*

b. Reassemble the battery pack (Section 7.1.2).

NOTE: *For a complete memory self-test, the instrument should be turned on for a minimum of 10 minutes for the Model 2860 and 18 minutes for the Model 2863. It is not necessary for the unit to be pumping to perform this test. If operating on battery power, a cassette must be installed in at least one of the channels and the channel in standby mode; otherwise, the instrument will automatically shut off after 5 minutes of inactivity.*

1. If a Watchdog 21 occurs, the EPROM module is defective and must be replaced.

7.5.2 Display Module and Component Repair

Tools required:

- #1 Phillips screwdriver
- 3/32-in. hex driver
- Grounded soldering iron
- Lint-free swabs
- Isopropyl alcohol

Disassembly

a. First, remove the following.

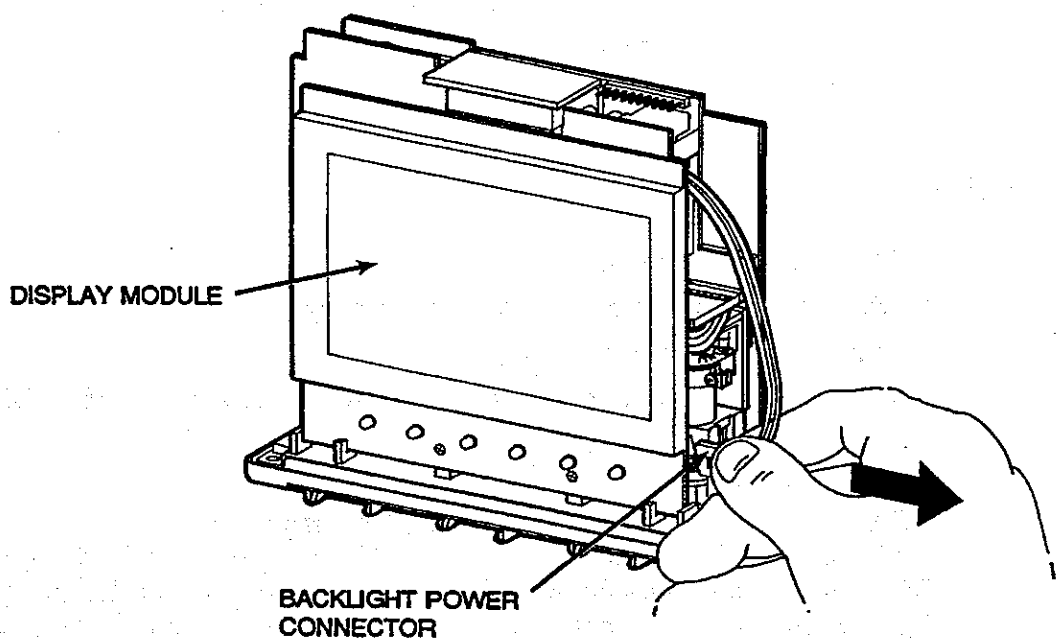
1. Lower housing (Section 7.1.1).
2. Battery pack (Section 7.1.2).

3. Main housing assembly (Section 7.1.3).

b. Remove the display module.

1. (For Model 2863 only) Remove the tie wrap holding the MEA top board down on the display module.
2. Remove the screws holding the display module from the chassis (on the Model 2863).
3. Unplug the backlight power connector on the side of the module (Figure 7-113).

Figure 7-113. Backlight Power Disconnection



CAUTION

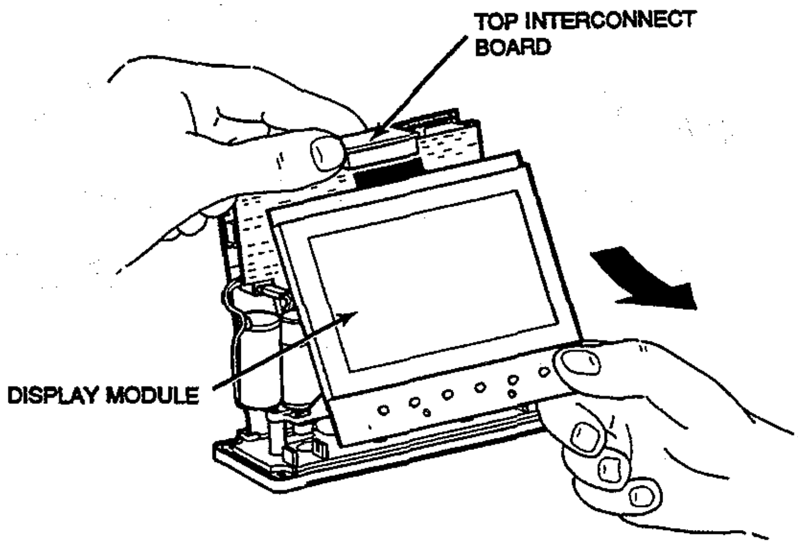
The backlight panel is powered by an 80V, 400-Hz source. Always be sure the instrument is turned off before the backlight power is disconnected from the display module.

4. Lift the module from the slots in the chassis and unplug it from the top interconnect board (Figure 7-114).

c. Inspect for the following.

1. Broken glass.
2. Damaged Kapton tape.

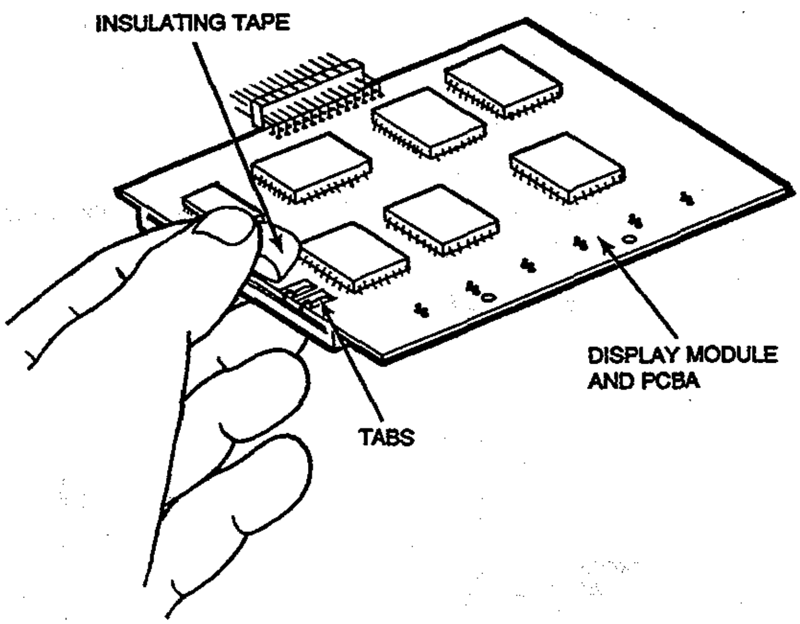
Figure 7-114. Display Module Removal



d. Replace the backlight panel.

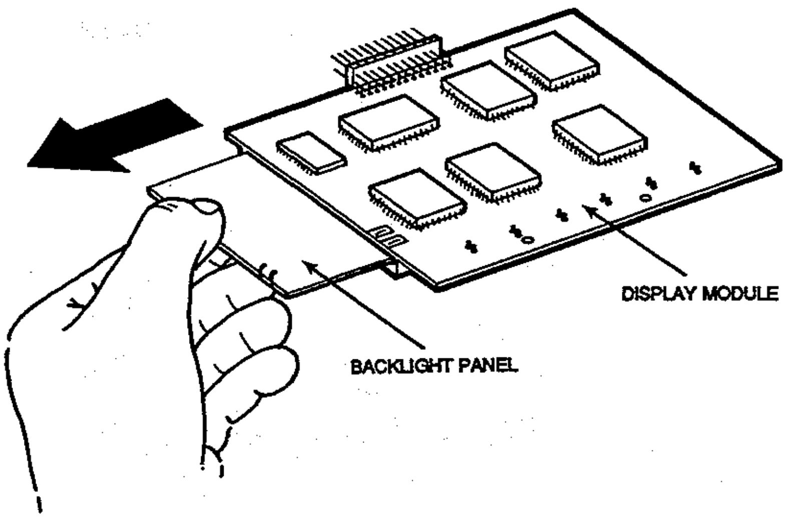
1. Remove the backlight panel by first peeling back the insulation tape to expose the two pads on the left side of the PCBA (GLASS facing down) (Figure 7-115).

Figure 7-115. Backlight Panel Tabs



2. Unsolder the two tabs for the backlight panel.
3. Slide the panel out (Figure 7-116).

Figure 7-116. Backlight Panel Removal

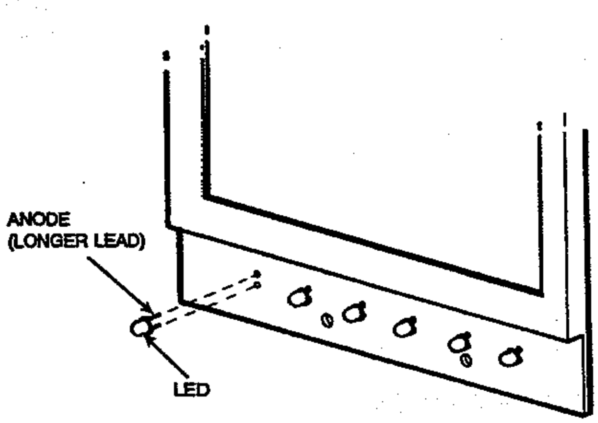


e. Replace the panel.
   1. Slide the new panels in so that the solder tabs align with the pads on the PCBA.
   2. Resolder and remove flux with isopropyl alcohol.
   3. Cover the contacts with Kapton tape.

> **CAUTION**
>
> *Do not overheat the solder tabs, as it could damage the PCBA and solder pads.*

f. Replace the LED indicator.
   1. Unsolder the desired LED.
   2. Insert the replacement LED such that the anode (longer lead) is in the bottom hole (Figure 7-117).

Figure 7-117. Display Module LED Insertion



3. Resolder and trim.
4. Remove flux with isopropyl alcohol.

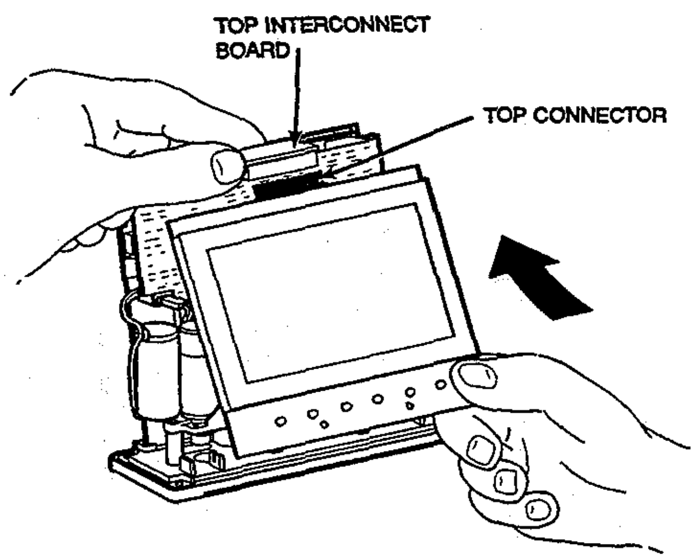
> **WARNING**
>
> *DO NOT use a substitute general purpose LED, as this could affect power supply monitoring functions.*

Reassembly

a. Reassemble in the following order.

1. Insert the top connector into the top interconnect board (Figure 7-118).

Figure 7-118. Display Module Top Connector Board Insertion



2. Replace the foam cushions at the two bottom corners of the board, if they are damaged or missing.
3. Seat the display module PCBA into the chassis slot (Figure 7-119).
4. Replace the screws, if applicable.
5. Attach the two-pin backlight power connector to the display module (Figure 7-120).
6. Ensure that the top interconnect board is properly seated.
7. (For Model 2863 only) Secure, using the tie wrap over the top interconnect board.
8. Reassemble in the following order.
   (a) Main housing assembly (Section 7.1.3).
   (b) Battery pack (Section 7.1.2).
   (c) Lower housing assembly (Section 7.1.1).

Figure 7-119. Display Module PCBA Insertion

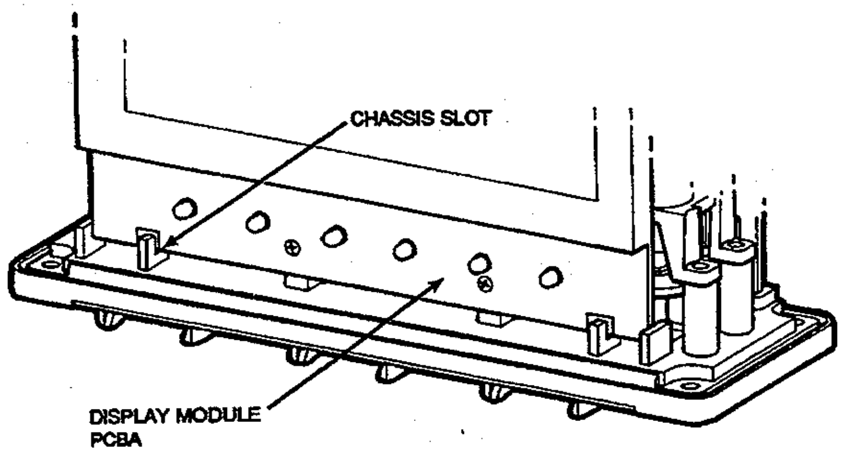
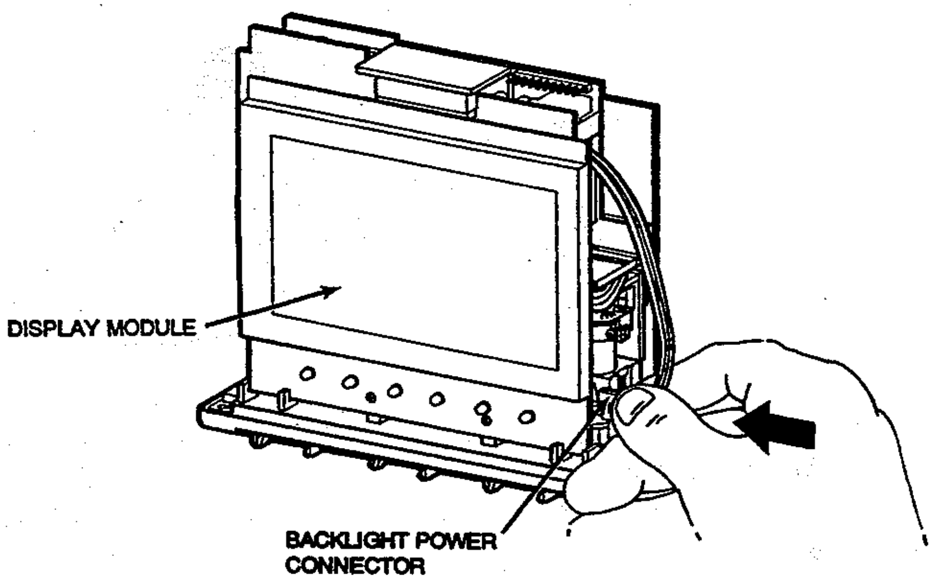


Figure 7-120. Backlight Power Connection



b. Recalibrate.

1. Memory contents may have been corrupted or lost during handling. Recalibrate (Chapter 5) if indicated when the instrument is turned on.

c. Test.

1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

d. Restore the settings.

1. If necessary, restore the customized settings and the Battery History Log, using FMS (refer to the FMS Directions For Use).

7.5.3 Backup Battery Replacement

Tools required:

- #1 Phillips screwdriver
- 3/32-inch hex driver

Disassembly

a. First, remove the following.

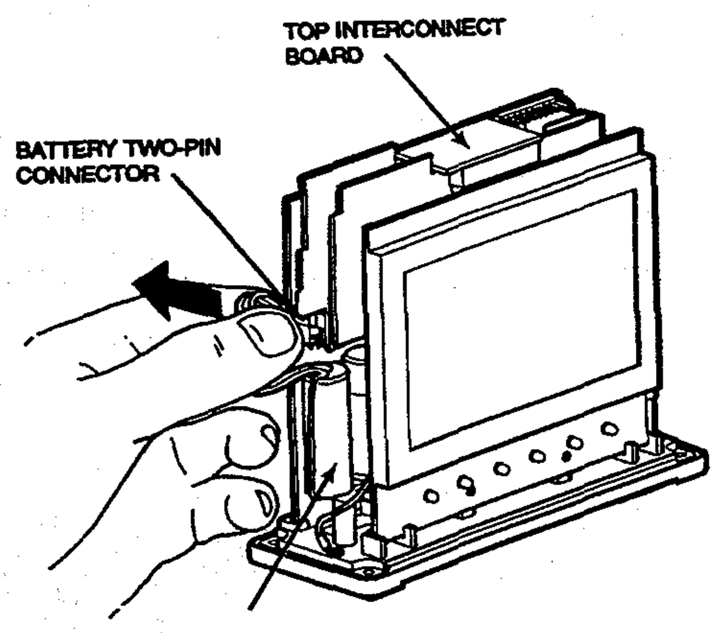
1. Lower housing assembly (Section 7.1.1).
2. Battery pack (Section 7.1.2).
3. Main housing assembly (Section 7.1.3).

NOTE: *If memory is corrupted, complete recalibration will be necessary. All custom instrument parameters originally set by using FMS will also require reprogramming.*

b. Check the voltage.

1. To prevent memory corruption when disconnecting backup battery, a NiCad battery must be connected and the instrument must be turned on. The instrument will automatically turn off after five minutes unless a cassette is installed in at least one channel.
2. Unplug the locking two-pin connector from the backup battery (Figure 7-121).

Figure 7-121. Backup Battery Connector



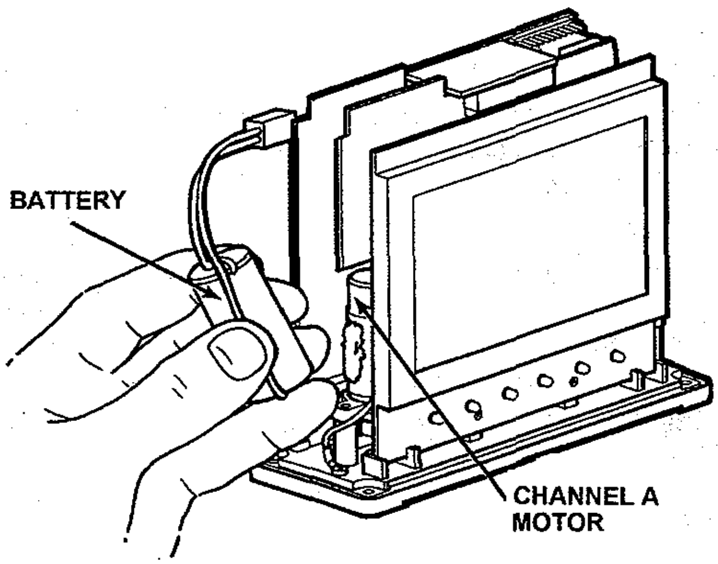
3. Measure the terminal voltage. If less than 2.5V, replace the battery.

c. Replace the following.

1. Remove the battery (Figure 7-122).

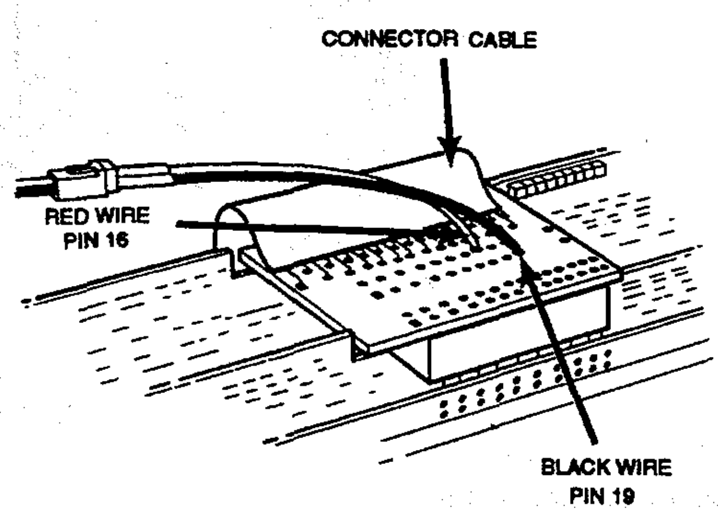
2. Remove any residual tape from the motor.
3. Remove the paper from the mounting tape and press the replacement battery to the Channel A motor.
4. Reconnect to the top interconnect board.

Figure 7-122. Backup Battery Removal



d. Replace the backup battery cable assembly.
   1. Remove the battery.
      (For Model 2860 only) Remove the mounting pad from the top interconnect board.
   2. Unsolder the cable assembly from the top interconnect board (Figure 7-123).

Figure 7-123. Backup Battery Cable Assembly Soldering Locations



3. (For Model 2860 only) Resolder a new cable to top interconnect board. Make sure that the cables are soldered to the correct inserts.
4. Reconnect the battery to the cable assembly.

> **CAUTION**
>
> *Use ONLY MedSystem III replacement batteries. DO NOT use any other type of battery. Doing so can damage the instrument.*

Reassembly

a. Reassemble in the following order.
   1. Main housing assembly (Section 7.1.3)
   2. Battery pack (Section 7.1.2)
   3. Lower housing assembly (Section 7.1.1)

b. Recalibrate.
   1. Turn on the instrument.
   2. If the memory contents have been corrupted, recalibrate all the sensor systems (Chapter 5).

c. Test.
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

d. Enter the battery installation date using FMS.

e. Restore the settings.
   1. If necessary, the customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.5.4 Power Supply Fuse Replacement

There are two different power supply PCBA layouts. Some versions (bottom mounted) have the fuse located on the backside of the board in the lower left corner, when you are facing the display (Figure 7-124). In other versions (top mounted), the fuse is located on the top edge to the left of the top interconnect board (Figure 7-125). The same fuse is used for both versions.

> **CAUTION**
>
> *Fuses are an off-the-shelf item. Use the following fuse manufacturer or equivalent: Little Fuse, Part No. 272003. If desired, these fuses can be purchased from IVAC. DO NOT substitute fuses of any other type or rating.*

Disassembly

Tools required:
- #1 Phillips screwdriver
- 3/32-inch hex driver

Figure 7-124. Bottom-mounted Power Supply Fuse

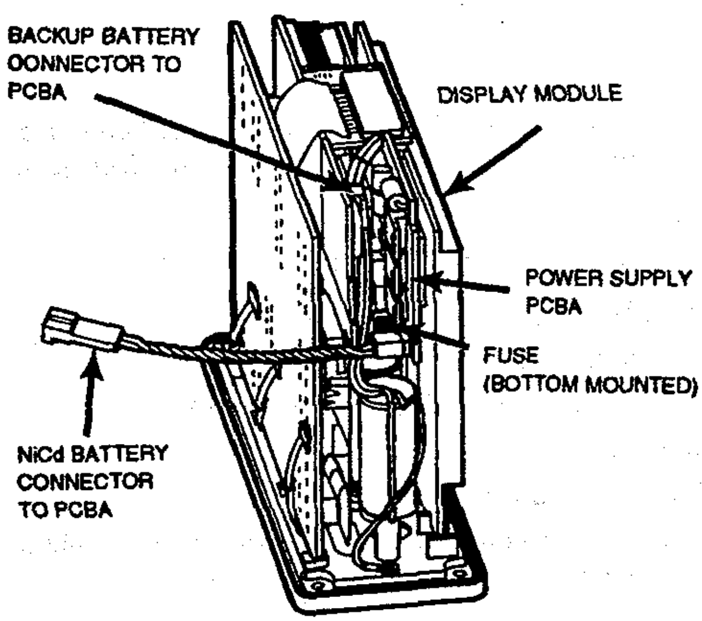
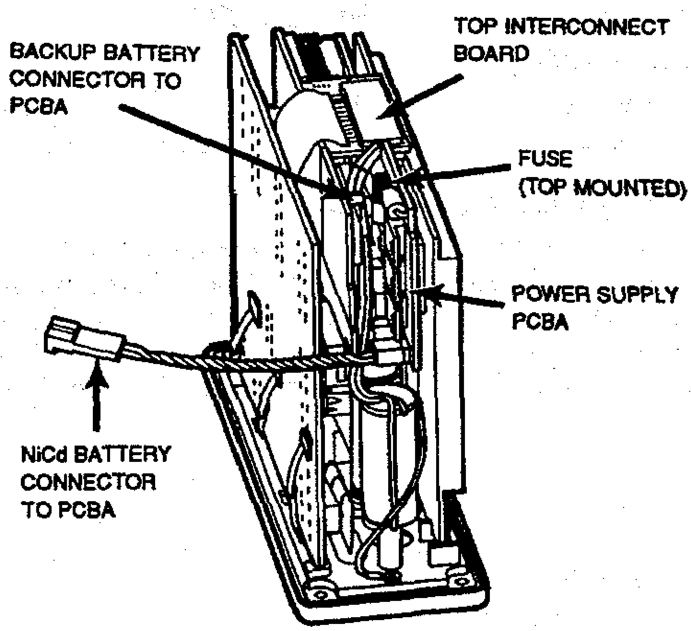


Figure 7-125. Top-mounted Power Supply Fuse



a. First, remove the following.
   1. Battery pack (Section 7.1.2).
b. Power Supply PCBA
   1. Top-mounted versions only
      (a) Remove the fuse.
      (b) Check the continuity and replace, if blown.

2. Bottom-mounted versions only
   (a) Remove the following.
      • Lower housing assembly (Section 7.1.1).
      • Unplug NiCad battery connector from power supply board.
      • Main housing assembly (Section 7.1.3).
      • Remove the fuse.
   (b) Check the fuse continuity and replace, if blown.

Reassembly

Reassemble in the following order.

a. Power supply PCBA
   1. Top-mounted versions only:
      • Battery pack (Section 7.1.2)
   2. Bottom-mounted versions only:
      • Main housing assembly (bottom-mounted version) (Section 7.1.3).
      • Battery pack (Section 7.1.2).
   3. Lower housing assembly (bottom-mounted version) (Section 7.1.1).

   Both Versions:

b. Recalibrate.
   1. Memory contents may have been corrupted or lost during handling. Recalibrate all sensor systems (Chapter 5), if indicated when the instrument is turned on.

c. Test.
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.

d. Restore the settings.
   1. The customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.5.5 Power Supply PCBA

Disassembly

Tools required:

- 3/32-inch hex driver
- #1 Phillips screwdriver
- 0.050-inch hex driver

a. First, remove the following.
   1. Lower housing (Section 7.1.1).
   2. Battery pack (Section 7.1.2).
   3. Main housing assembly (Section 7.1.3).
   4. Display module (Section 7.5.2).

b. Remove the following.

1. Using a #1 Phillips screwdriver, remove the screw securing the green ground wire from the power supply to the chassis (Figure 7-126).
2. Remove the two power supply PCBA mounting screws, using the 0.050-inch hex driver bit (Figure 7-127).
3. Set aside the insulating washers.

Figure 7-126. Ground Wire Disconnection

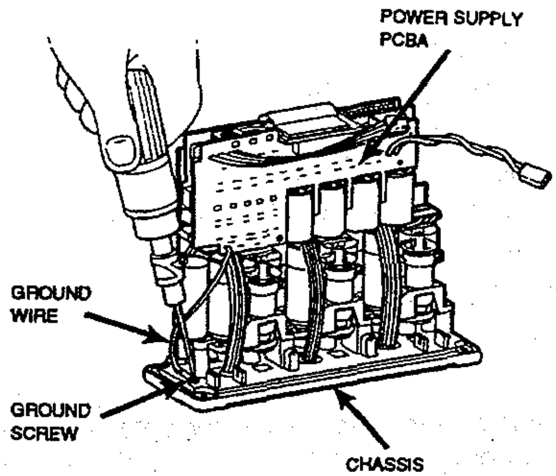
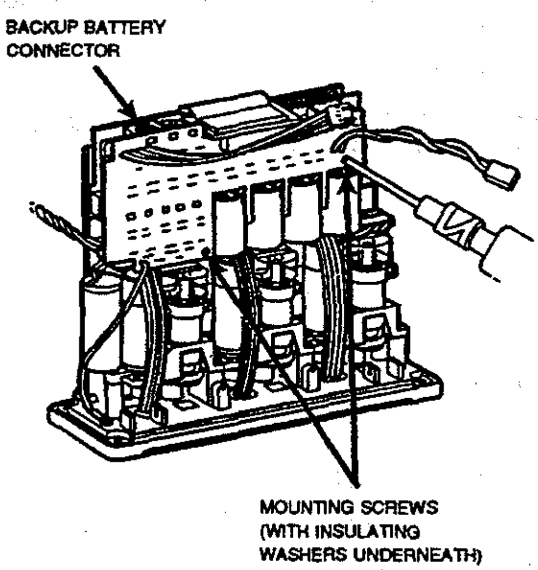


Figure 7-127. Power Supply PCBA Mounting Screws



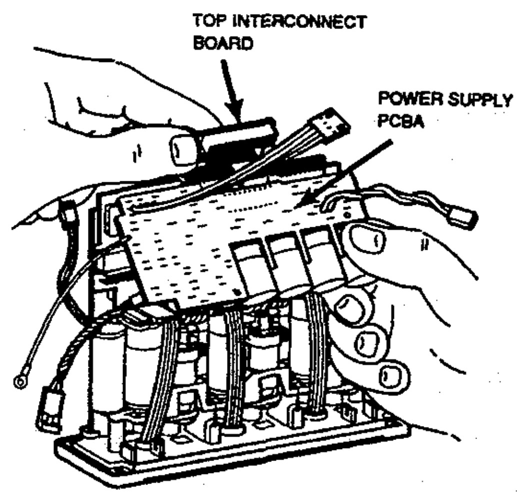
4. Unplug the power supply from the A/C PCBA and remove (Figure 7-128).

c. Inspect for the following.

1. Ground wire for breaks.
2. EL backlighting connector wires.

3. Audio/connector PCBA.
4. Ensure that the inductors are securely attached to the power supply PCBA.

Figure 7-128. Power Supply PCBA Removal



Reassembly

a. Reassemble in the following order.
   1. Install the insulating washers on the mounting screws, using a 0.050-inch hex driver.
   2. Secure the PCBA to the MEA.
   3. Plug in the top interconnect board.
   4. With a ground screw and washer, attach the ground wire to the chassis, using a #1 Phillips screwdriver.
   5. Reassemble the remaining components in the following order.
      (a) Display module (Section 7.5.2).
      (b) Main housing assembly (Section 7.1.3).
      (c) Battery pack (Section 7.1.2).
      (d) Lower housing assembly (Section 7.1.1).

b. Recalibrate.
   1. All sensor systems must be recalibrated because supply voltages may have been changed (Chapter 5).

c. Test
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.
   2. Include the battery operating time if the power supply PCBA was replaced.

d. Restore the settings.
   1. The customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).

7.5.6 Main Electronics Assembly

Tools required:

- 3/32-inch hex driver
- 0.050-inch hex driver
- #1 Phillips screwdriver
- Needle-nose pliers or tweezers
- X-ACTO knife
- 0.5-inch length of 0.25-inch-diameter heat-shrink tubing (must be UL 224 or CSA 198 approved, e.g., Alpha FIT-221)

Disassembly

a. First, remove the following.

1. Lower housing (Section 7.1.1).
2. Battery pack (Section 7.1.2).
3. Main housing (Section 7.1.3).
4. Display module (Section 7.5.2).
5. Power supply PCBA (Section 7.5.5).

b. Remove the MEA.

1. Disconnect in order the following from the MEA.
   (a) Memory backup battery (Section 7.5.3).
   (b) Air-in-line sensors (Section 7.4.1).
   (c) Motors (Section 7.4.2).
   (d) Pressure transducers (Section 7.4.2).
   (e) Encoders (Section 7.4.2).
2. (For Model 2863 only) Remove the screws holding the MEA to the chassis.
3. Lift the assembly from the chassis guides and lay it on a table or other flat surface (Figure 7-129).

Figure 7-129. Main Electronics Assembly Separation from Chassis (Model 2860)

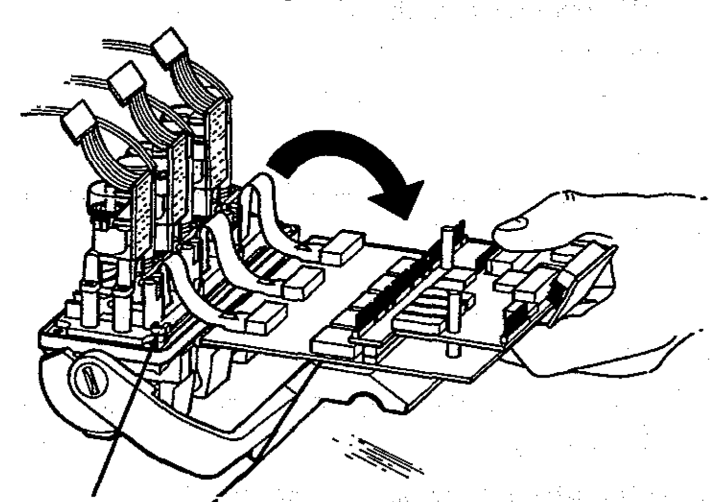
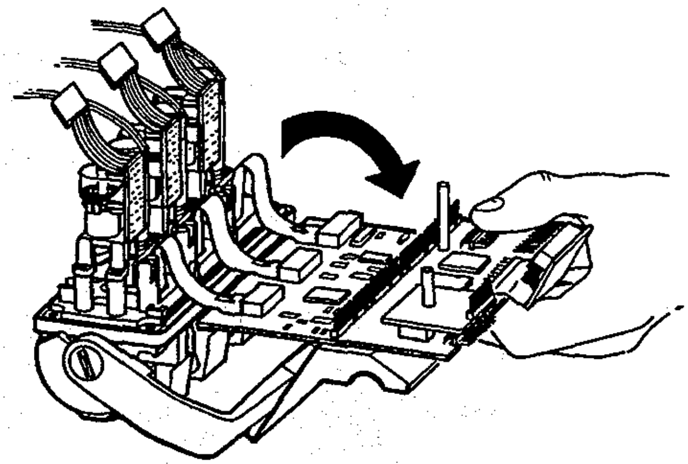
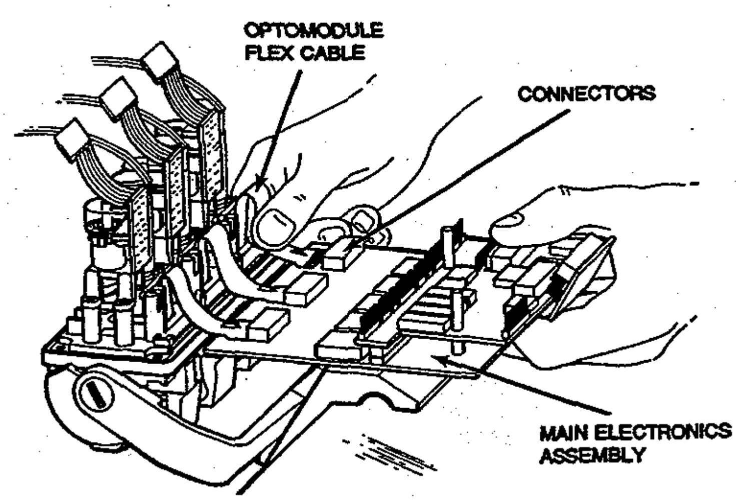


Figure 7-130. Main Electronics Asssembly Separation from Chassis (Model 2863)



4. Disconnect the optomodule flex cables from the locking connection (see Figure 7-131 and Section 7.4.2).

Figure 7-131. Optomodule Flex Disconnection



CAUTION: *(For Model 2860 only) DO NOT attempt to separate the auxiliary board from the mother board, as this requires special equipment and could cause damage.*

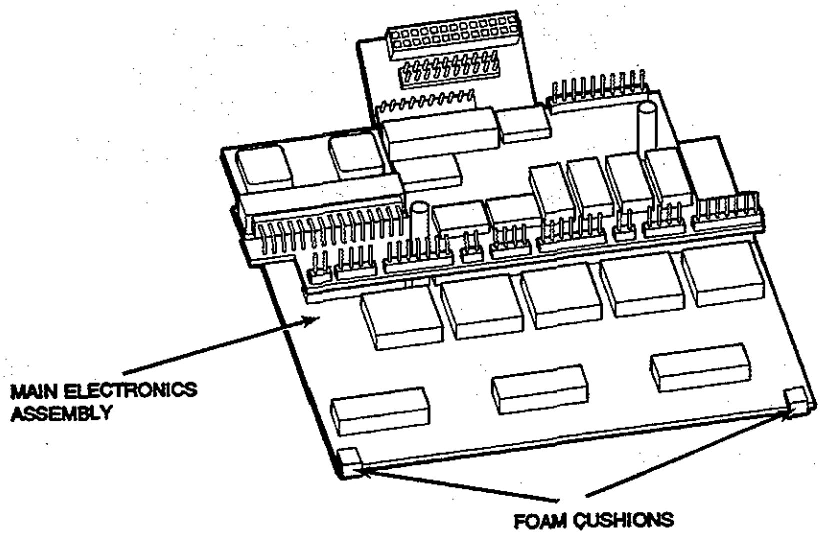
c. Inspect for the following.
   1. Loose stand-offs.
   2. Damaged foam pads on lower corners.
   3. Damaged optomodule flex cable.
   4. Damaged motor, pressure transducer, and encoder leads.
   5. Worn drive belts.
   6. Worn pump shaft sleeve bearings (if applicable).

Reassembly

a. Reassemble in the following order.

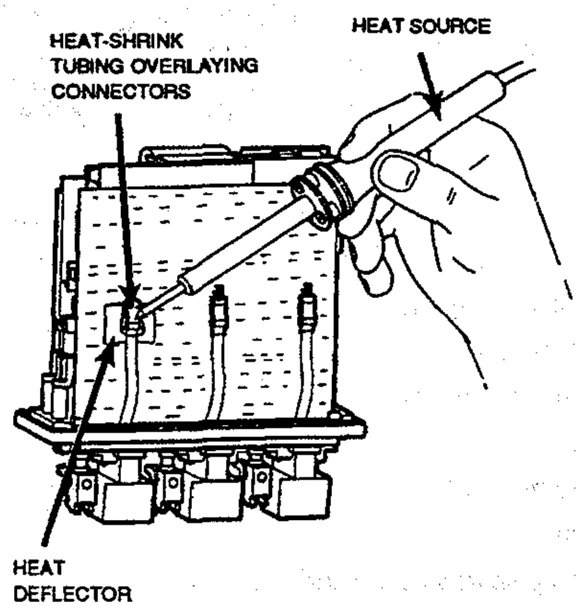
1. (For Model 2860 only) Replace the foam cushions at the two bottom corners of the board, if they are missing or damaged (Figure 7-132).

Figure 7-132. Main Electronics Assembly Foam Cushions (Model 2860 only)



2. Insert the optomodule flex into the appropriate connector. Ensure the flexes are aligned properly and seated squarely; then seat the connector.
3. (For Model 2860 only) Slide a 0.5-inch piece of 0.25-inch UL-approved heat-shrink tubing over the air-in-line sensor flex (Figure 7-133). Mate the connector to the MEA and slide the heat-shrink to cover both connectors. Use a thin heat deflector under the connector to prevent thermal damage. Apply heat.

Figure 7-133. Heat-shrink Tubing Installation (Model 2860 only)



4. (For Model 2863 only) Connect the ultrasensor tail flexes to the main board assembly. Fold the ultrasensor tail flexes so the outside loop is down and against the circuit board. Apply a 1-1/2" ± 1/4" of 1/4" Kapton tape on the folded area.
5. Attach the remaining connectors, starting with the encoder, followed by the pressure transducer and then the motor (Figure 7-134 and 7-135). Make sure that they are oriented properly. The cables must not be crossed or twisted.
6. (For Model 2863 only) Reattach the MEA to the chassis with the screws.
7. Ensure that the pins are properly aligned.

Figure 7-134. Motor, Pressure Transducer, and Encoder Reconnection (Model 2860)

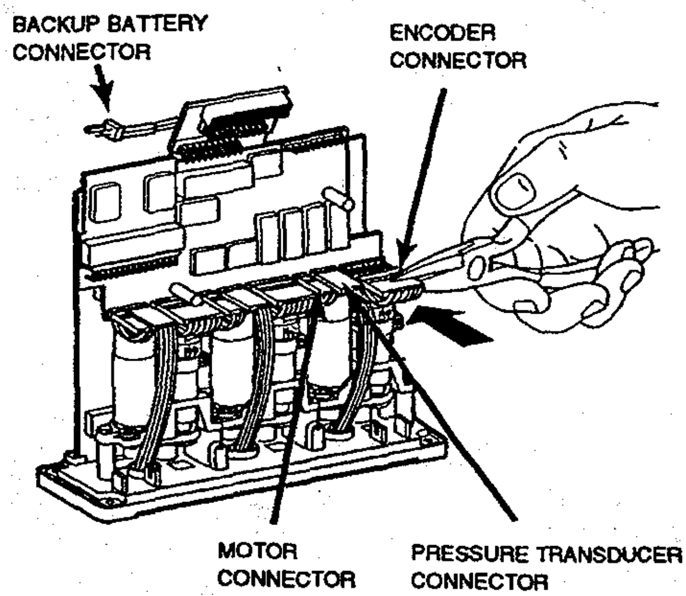
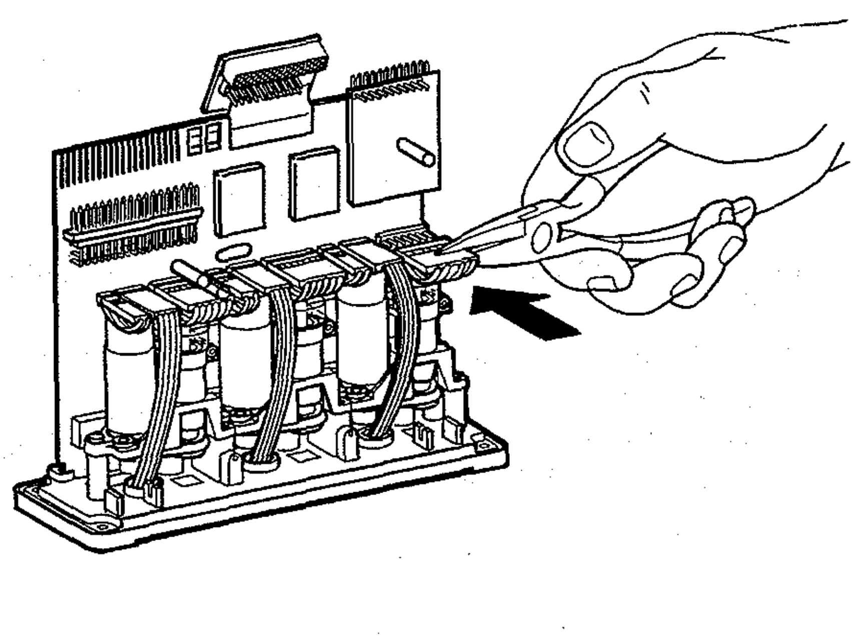


Figure 7-135. Motor, Pressure Transducer, and Encoder Reconnection (Model 2863)

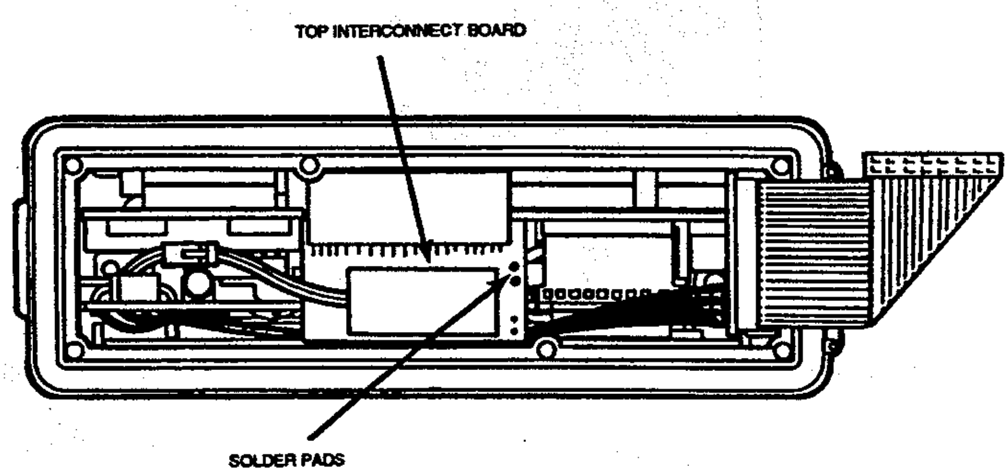


8. Reassemble the remaining components in the following order.
   (a) Power supply PCBA (Section 7.5.5).
   (b) Display module (Section 7.5.2).
   (c) Memory backup battery connector (Section 7.5.3).
   (d) Main housing assembly (Section 7.1.3).
   (e) Battery pack (Section 7.1.2).
   (f) Lower housing assembly (Section 7.1.1).

b. Reinitialize RAM (Figure 7-136).

c. Occasionally RAM contents are corrupted during normal use or after repair. The corrupted data is detected by the software and results in either an instrument fault or a watchdog. In these situations the service personnel must initialize RAM by shorting the two solder pads on the top interconnect board. Shorting these pads during power-up causes the software to initialize the RAM. After initialization the instrument must be calibrated (refer to Chapter 5), and custom parameters must be reprogrammed (refer to Troubleshooting Section 6.4.2).

Figure 7-136. RAM Initialization



d. Recalibrate.
   1. All sensor systems must be recalibrated (Chapter 5).

e. Test.
   1. Perform run-in (Section 7.1) and all the functional checks (Chapter 3) except for the battery.
   2. Include the battery operating time if the MEA was replaced.

f. Restore the settings.
   1. The customized settings and the Battery History Log should be restored using FMS (refer to the FMS Directions For Use).